
Baseline Human Health Risk Assessment for the Harbor Oil Study Area

Prepared for the Voluntary Group
for the Harbor Oil Site RI/FS
FINAL

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WINDWARD ENVIRONMENTAL LLC

IN ASSOCIATION WITH
BRIDGEWATER GROUP, INC.

CONTENTS

CONTENTS.....	I
List of Tables	iv
List of Figures	vii
List of Acronyms	ix
EXECUTIVE SUMMARY	ES-1
ES.1 Data Evaluation.....	ES-1
ES.2 Conceptual Site Model and Exposure Assessment	ES-2
ES.3 Toxicity Assessment	ES-4
ES.4 Risk Characterization and Uncertainty Analysis	ES-4
1.0 INTRODUCTION	1
1.1 Document Purpose and Scope	1
1.2 Study Area Location and Facility Description	1
2.0 DATA EVALUATION	7
2.1 Data Availability and Selection.....	7
2.1.1 Historical Datasets	7
2.1.1.1 Criteria for Historical Data Screen	9
2.1.1.2 Historical Data Screen Results	10
2.1.2 Data Acceptable for Use in the Baseline HHRA	10
2.2 Data Reduction	15
2.2.1 Duplicate or Replicate Samples	15
2.2.2 Selection of Best Results	15
2.2.3 Significant Figures and Rounding	16
2.2.4 Calculating Totals.....	16
2.2.5 Aliphatic TPH.....	18
2.3 Suitability of Data for Risk Assessment.....	19
2.3.1 Representativeness to Study Area Concentrations	19
2.3.2 Representativeness to Expected Human Exposure	20
2.3.3 Quality Assurance/Quality Control Results	20
2.3.4 Other Factors	20
2.3.4.1 Documentation of Field and Laboratory Practices	20
2.3.4.2 Analytical Data Review	20
2.3.4.3 Analytical Methods.....	21
3.0 EXPOSURE ASSESSMENT	23
3.1 Conceptual Site Model.....	23
3.1.1 Industrial (Construction/Trenching) Worker RME Scenario	29
3.1.2 Future Outdoor Worker RME Scenario.....	30
3.1.3 Industrial/Commercial Worker Vapor Intrusion Scenario	31

3.1.4 Force Lake Recreational User RME Scenario	33
3.1.5 Force Lake Fish Consumer RME Scenario	34
3.1.6 Selection of Exposure Scenarios for Quantification	36
3.2 COPC Screening and Evaluation	36
3.2.1 RSLs for COPC Screen or Screening-Level Assessment	37
3.2.1.1 Exposure to Groundwater and Lake Surface Water	38
3.2.1.2 Exposure to Soil (Industrial)	38
3.2.1.3 Exposure to Soil (Residential or Recreational)	39
3.2.1.4 Exposure to Lake Sediment (Residential or Recreational)	39
3.2.1.5 Fish Tissue Consumption	39
3.2.2 Scenario-Specific COPCs	39
3.3 Selection of Exposure Parameters and Calculation of Chronic Daily Intake	47
3.3.1 Chronic Daily Intake Rate Calculations	47
3.3.2 Exposure Parameters	51
3.3.3 Fish Consumption Rate	69
3.3.3.1 April 2009 Force Lake Fish Survey	69
3.3.3.2 Study Area-Specific Information Regarding Fishing at Force Lake	70
3.3.3.3 Selected Fish Consumption Rate	70
3.3.4 Dermal Absorption Fractions	72
3.3.5 Calculation of Exposure Concentrations	74
3.3.6 Evaluation of Exposures to Lead	84
3.3.6.1 Children (IEUBK)	84
3.3.6.2 Adult (ALM)	86
3.4 Chronic Daily Intake	89
4.0 TOXICITY ASSESSMENT	91
5.0 RISK CHARACTERIZATION	107
5.1 Risk Estimate Calculations	107
5.1.1 Carcinogenic Risks	107
5.1.2 Non-Carcinogenic Risks	109
5.2 Risk Characterization Format	110
5.3 Risk Characterization Results	111
5.3.1 Industrial (Construction/Trenching) Worker	112
5.3.2 Future Outdoor Worker	119
5.3.3 Industrial/Commercial Worker Vapor Intrusion	124
5.3.3.1 Current Facility Buildings	124
5.3.3.2 Hypothetical/Future Facility Buildings	125
5.3.4 Force Lake Recreational User	126
5.3.5 Force Lake Fish Consumer	134
5.4 Lead Modeling Results	139
5.4.1 Children (IEUBK)	139
5.4.2 Adults (ALM)	141
5.5 Risk Characterization Summary	142
6.0 UNCERTAINTY ANALYSIS	147
6.1 Exposure Assessment	150

6.1.1 Exposure Point Concentrations.....	150
6.1.1.1 EPC Estimates for Small Datasets	150
6.1.1.2 EPC Estimates for Infrequently Detected COPCs.....	151
6.1.2 Dermal Absorption Fractions.....	151
6.1.3 Force Lake Recreational User Exposure Frequency	153
6.1.4 Calculation of Contaminant Concentrations in Fish Tissue Using BSAFs.....	153
6.1.5 Fish Consumption Rate.....	155
6.2 Toxicity Assessment	158
6.2.1 Chemicals without RSLs	158
6.2.2 COPCs without Toxicity Values	162
6.3 Risk Characterization	162
6.3.1 Non-Detected COPCs	163
6.3.2 Risks to Current Outdoor Workers	176
7.0 CONCLUSIONS.....	179
7.1 Arsenic.....	181
7.2 cPAH TEQ	182
7.3 Total PCBs	182
7.4 Total DDTs.....	182
7.5 TPH-gasoline (aliphatic).....	183
8.0 REFERENCES	185

ATTACHMENT 1	HYPOTHETICAL FUTURE RESIDENT SCREENING ASSESSMENT
ATTACHMENT 2	METHODS FOR CALCULATING FISH TISSUE CONCENTRATIONS
ATTACHMENT 3	SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
ATTACHMENT 4	CALCULATION OF OUTDOOR AIR VAPOR CONCENTRATIONS FOR INHALATION RISKS
ATTACHMENT 5	CDI RATES, INHALATION ECs, AND DERMALLY ABSORBED DOSES FOR CONTAMINANTS OF POTENTIAL CONCERN
ATTACHMENT 6	TOXICOLOGICAL PROFILES FOR CONTAMINANTS OF POTENTIAL CONCERN
ATTACHMENT 7	BACKGROUND AND REFERENCE AREA CONCENTRATIONS

List of Tables

Table ES-1. Summary of Total Excess Cancer Risks and Non-Cancer HQs	ES-5
Table 2-1. Datasets Reviewed for Data Quality and Documentation for the Harbor Oil RI	8
Table 2-2. Results of Data Screen of Historical Datasets	11
Table 2-3. Summary of Data Used in the Baseline HHRA by Sampling Event	13
Table 2-4. Summary of Data Used in the Baseline HHRA	14
Table 2-5. Potency Equivalency Factors for cPAHs	18
Table 3-1. Rationale for the Selection or Exclusion of Exposure Pathways	27
Table 3-2. COPCs for the Industrial (Construction/Trenching) Worker RME Scenario	40
Table 3-3. COPCs for the Future Outdoor Worker RME Scenario	42
Table 3-4. COPCs for the Industrial/Commercial Worker Vapor Intrusion Scenario	43
Table 3-5. COPCs for the Force Lake Recreational User RME Scenario	44
Table 3-6. COPCs for the Force Lake Fish Consumer RME Scenario	46
Table 3-7. Summary of COPCs by Scenario	47
Table 3-8. Daily Intake Calculations – Incidental Ingestion of Soil During Industrial (Construction/Trenching) Work	52
Table 3-9. Daily Intake Calculations – Dermal Contact with Soil During Industrial (Construction/Trenching) Work	53
Table 3-10. Daily Intake Calculations – Dermal Contact with Groundwater During Industrial (Construction/Trenching) Work	54
Table 3-11. Daily Intake Calculations – Inhalation of COPCs from Soil/Water During Industrial (Construction/Trenching) Work	55
Table 3-12. Daily Intake Calculations – Incidental Ingestion of Soil During Future Outdoor Work	56
Table 3-13. Daily Intake Calculations – Dermal Contact with Soil During Future Outdoor Work	57
Table 3-14. Daily Intake Calculations – Inhalation of COPCs from Soil During Future Outdoor Work	58
Table 3-15. Daily Intake Calculations – Incidental Ingestion of Soil or Sediment During Force Lake Recreation	59
Table 3-16. Daily Intake Calculations – Dermal Contact with Soil or Sediment During Force Lake Recreation	61
Table 3-17. Daily Intake Calculations – Incidental Ingestion of Surface Water During Force Lake Recreation	63
Table 3-18. Daily Intake Calculations – Dermal Contact with Surface Water During Force Lake Recreation	65
Table 3-19. Daily Intake Calculations – Consumption of Fish Tissue from Force Lake	67
Table 3-20. Hypothetical Fish Catch Rates for Six Anglers Consuming Six Meals per Year from Force Lake	71
Table 3-21. Dermal Absorption Fractions	73

Table 3-22. Exposure Point Concentrations and Summary Statistics for the Baseline HHRA	76
Table 3-23. Summary of EPCs Used in Baseline HHRA	81
Table 3-24. Input parameters for IEUBK lead model	85
Table 3-25. Input Parameters for ALM	87
Table 3-26. Summary of Lead Data and Mean EPC Values	88
Table 4-1. Non-Cancer Toxicity Data (Oral/Dermal) for COPCs	93
Table 4-2. Non-Cancer Toxicity Data (Inhalation) for COPCs	96
Table 4-3. Cancer Toxicity Data (Oral/Dermal) for COPCs	99
Table 4-4. Cancer Toxicity Data (Inhalation) for COPCs	101
Table 4-5. Toxicological Endpoints by Exposure Pathway for COPCs with Non-Carcinogenic Effects	104
Table 5-1. Excess Cancer Risk Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Facility Soil	113
Table 5-2. Excess Cancer Risk Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Groundwater	114
Table 5-3. Non-Cancer Hazard Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Facility Soil	115
Table 5-4. Non-Cancer Hazard Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Groundwater	117
Table 5-5. Excess Cancer Risk Estimates Across Scenarios	118
Table 5-6. Comparison of Study Area and Background or Reference Area Soil Exposure Concentrations and Risk Estimates for the Industrial (Construction/Trenching) Worker RME Scenario	119
Table 5-7. Excess Cancer Risk Estimates for the Future Outdoor Worker RME Scenario	120
Table 5-8. Non-Cancer Hazard Estimates for the Future Outdoor Worker RME Scenario	121
Table 5-9. Comparison of Study Area and Background or Reference Area Soil Exposure Concentrations and Excess Cancer Risk Estimates for the Future Outdoor Worker Scenario Based on Exposure to Facility Soil	123
Table 5-10. Risk Estimates for the Industrial/Commercial Worker Vapor Intrusion Scenario	125
Table 5-11. Cumulative Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario Based on Exposure to Wetland Soil	126
Table 5-12. Cumulative Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Sediment	127
Table 5-13. Cumulative Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Surface Water	127
Table 5-14. Non-Cancer Hazard Estimates for the Force Lake Recreational User RME Scenario Based on the Exposure of Children Aged 0 to 6 to Wetland Soil	129
Table 5-15. Non-Cancer Hazard Estimates for the Force Lake Recreational User RME Scenario Based on the Exposure of Children Aged 0 to 6 to Lake Sediment	130

Table 5-16. Non-Cancer Hazard Estimates for the Force Lake Recreational User RME Scenario Based on the Exposure of Children Aged 0 to 6 to Lake Surface Water	130
Table 5-17. Weighted Non-Cancer Hazard Estimates for 0 to 30-yr Exposure Duration for the Force Lake Recreational User RME Scenario Based on Exposure to Wetland Soil	131
Table 5-18. Weighted Non-Cancer Hazard Estimates for 0 to 30-yr Exposure Duration for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Sediment	132
Table 5-19. Weighted Non-Cancer Hazard Estimates for 0 to 30-yr Exposure Duration for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Surface Water	132
Table 5-20. Total Risk Estimates Across Media for the Force Lake Recreational User RME Scenario	133
Table 5-21. Comparison of Study Area and Background or Reference Area Soil or Sediment Exposure Concentrations and Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario	134
Table 5-22. Integrated Lifetime Excess Cancer Risk Estimate for the Force Lake Fish Consumer RME Scenario	135
Table 5-23. Non-Cancer Hazard Estimate for the Force Lake Fish Consumer RME Scenario Based on the Exposure of Children Aged 0 to 6 Years	136
Table 5-24. Weighted Non-Cancer Hazard Estimate for 0 to 30-yr Exposure Duration for the Force Lake Fish Consumer RME Scenario	137
Table 5-25. Comparison of Study Area and Background or Reference Area Exposure Concentrations and Lifetime Excess Cancer Risk Estimates for the Force Lake Fish Consumer Scenario	138
Table 5-26. Risk Estimates for Predicted Fetal and Adult Lead Levels Using the Adult Lead Model	141
Table 5-27. Summary of Total Excess Cancer Risks and Non-Cancer HQs	142
Table 5-28. Summary of Excess Cancer Risks for Scenarios with Total Excess Cancer Risks Greater than or Equal to 1×10^{-6}	144
Table 5-29. Excess Cancer Risk Estimates Across Scenarios	146
Table 6-1. Summary of Uncertainties Identified in the Baseline HHRA	148
Table 6-2. Risk Estimates Using a Range of Dermal Absorption Values for Cobalt	152
Table 6-3. Fish BSAFs Used in the HHRA	153
Table 6-4. Risk Calculations Across a Range of BSAFs	154
Table 6-5. Risk Estimates Across Fish Consumption Rates	156
Table 6-6. Number of Fish Needed for Six Anglers Consuming Fish from Force Lake Under Various Consumption Rate Scenarios	157
Table 6-7. Chemicals Without Soil RSLs	158
Table 6-8. Chemicals Without Water RSLs	160
Table 6-9. Chemicals Without Fish RSLs	161
Table 6-10. Summary of COPCs with Non-Detected Concentrations for the Industrial (Construction/Trenching) Worker RME Scenario Based on Exposure to Facility Soil	164

Table 6-11. Summary of COPCs with Non-Detected Concentrations for the Industrial (Construction/Trenching) Worker RME Scenario Based on Exposure to Groundwater	165
Table 6-12. Summary of COPCs with Non-Detected Concentrations for the Future Outdoor Worker RME Scenario Based on Exposure to Facility Soil	167
Table 6-13. Summary of COPCs with Non-Detected Concentrations for the Industrial/Commercial Worker Vapor Intrusion Scenario Based on Exposure to Groundwater	168
Table 6-14. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Wetland Soil	169
Table 6-15. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Sediment	171
Table 6-16. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Surface Water	172
Table 6-17. Summary of COPCs with Non-Detected Concentrations for the Force Lake Fish Consumer RME Scenario Based on Exposure to Calculated Fish Tissue	174
Table 7-1. Summary of Total Excess Cancer Risks and Non-Cancer HQs	180
Table 7-2. Summary of Risk Estimates and Percent Contribution of Total Risk for each COC	181

List of Figures

Figure ES-1. Proportion of Total Excess Cancer Risks for Each COC and for other COPCs	ES-7
Figure 1-1. Harbor Oil Study Area	4
Figure 1-2. Current Facility Features	5
Figure 2-1. Sampling Locations for Data Used in the Baseline HHRA	12
Figure 3-1. Human Health CSM	26
Figure 3-2. Sampling Locations for the Industrial/Commercial Worker Vapor Intrusion Scenarios	32
Figure 3-3. Human health COPC screening process	37
Figure 5-1. Probability Density Curves for Predicted Blood Lead Concentrations Using Input Data from the Children's Force Lake Recreational User RME Scenario and Force Lake Fish Consumer RME Scenario	140
Figure 6-1. Excess Cancer Risk Estimates across Fish Consumption Rates	156

List of Acronyms

ABS	dermal absorption fraction
ALM	Adult Lead Model
AOC	Administrative Settlement Agreement and Order on Consent for the Remedial Investigation/Feasibility Study
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	ambient water quality criteria
BaP	benzo[a]pyrene
BCA	bias-corrected accelerated
BHC	benzene hexachloride
BSAF	biota-sediment accumulation factor
Cal EPA	California Environmental Protection Agency
CDC	Centers for Disease Control
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COI	contaminant of interest
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSM	conceptual site model
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DEQ	Oregon Department of Environmental Quality
DQO	data quality objective
dw	dry weight
EC	exposure concentration
EDB	ethylene dibromide
EF	exceedance factor
EMRI	Energy & Material Recovery, Inc.
EPC	exposure point concentration
EPA	US Environmental Protection Agency

Facility	Harbor Oil facility
GI	gastrointestinal
GSD	geometric standard deviation
H-UCL	UCL based on Land's H-statistic
HCID	hydrocarbon identification
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HQ	hazard quotient
IARC	International Agency for Research on Cancer
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children
IRIS	Integrated Risk Information System
J-qualifier	estimated concentration
KM	Kaplan Meier method for calculating a UCL
LNAPL	light non-aqueous phase liquid
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MEL	Manchester Environmental Laboratory
NRMP	natural resource management plan
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEF	particulate emission factor
PPRTV	Provisional Peer-Reviewed Toxicity Value
QA/QC	quality assurance/quality control
ODHS	Oregon Department of Human Services
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RBC	risk-based concentration
RfC	reference concentration
RfD	reference dose
RFO	refined fuel oil
RI/FS	remedial investigation/feasibility study

RL	reporting limit
RME	reasonable maximum exposure
RSL	regional screening level
RZA	Rittenhouse-Zeman and Associates
SD	standard deviation
SF	slope factor
Study Area	Harbor Oil Superfund Study Area
SVOC	semivolatile organic compound
TEQ	toxic equivalent
TPH	total petroleum hydrocarbons
TPH-Dx	total petroleum hydrocarbons-diesel and oil extractable
TPH-G	total petroleum hydrocarbons-gasoline
TPH-HCID	total petroleum hydrocarbons-hydrocarbon identification
UCL	upper confidence limit on the mean
U-qualifier	not detected at given concentration
UF	uncertainty factor
VOC	volatile organic compound
Windward	Windward Environmental LLC
ww	wet weight

EXECUTIVE SUMMARY

This document presents the baseline human health risk assessment (HHRA) for the Harbor Oil Superfund Site Study Area¹ in Portland, Oregon. This baseline HHRA presents risk estimates for humans associated with potential exposures to contaminants found in soil, lake sediment, lake water, groundwater, and fish caught in Force Lake. The exposure scenarios and assumptions assessed in this HHRA are consistent with a reasonable maximum level of exposure, and thus, although uncertain, risk estimates are intended to be health protective for individuals.

Overall, risks at the Study Area were low for workers at the Facility and for individuals using the off-Facility portions of the Study Area for recreation. Total risks for all scenarios were less than the upper end of the US Environmental Protection Agency's (EPA's) target risk range (1×10^{-4}), although risks for some scenarios were greater than the lower end of EPA's target risk range (1×10^{-6}). Risks were highest for the fish consumption and future outdoor worker scenarios (2×10^{-5} for both scenarios). Risks based on the industrial (construction/trenching) worker (3×10^{-6}) and recreational user scenarios (which ranged from 1×10^{-7} to 9×10^{-6} for the various exposure media) were also greater than the lower end of EPA's target risk range. No contaminant of potential concern (COPC)-specific hazard quotients (HQs) or endpoint-specific hazard indices (HIs) were greater than 1 for any scenario. Based on their risk levels and contribution to the total risk, arsenic, carcinogenic polycyclic aromatic hydrocarbon (cPAH) toxic equivalent (TEQ), total polychlorinated biphenyls (PCBs), total dichlorodiphenyltrichloroethanes (DDTs), and total petroleum hydrocarbons (TPH)-gasoline (aliphatic) were identified as contaminants of concern (COCs) in this HHRA.

The baseline HHRA includes sections on data evaluation, conceptual site model (CSM) and exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis, each of which is briefly summarized below.

ES.1 Data Evaluation

Data used in the assessment included data collected from within the Study Area during the two phases of remedial investigation (RI) data collection (April 2008 and April 2009). In addition, one of the eight historical datasets available for the Study Area was found to be acceptable for use in this HHRA. The historical data used in the HHRA

¹ The Harbor Oil Superfund Site encompasses the Harbor Oil facility (Facility), an approximately 4.1-acre parcel of property located at 11535 N Force Avenue, the adjacent wetlands to the south and west of Force Lake, and Force Lake.

were collected by EPA in 2000 (Ecology and Environment 2001). In total, the HHRA dataset included Facility soil samples, groundwater samples, wetland soil samples, lake sediment samples, and lake surface water samples. The available data were found to be representative of Study Area concentrations and appropriate for use in estimating potential human exposures.

ES.2 Conceptual Site Model and Exposure Assessment

The CSM describes scenarios in which people could be exposed to chemicals within the Study Area through various exposure pathways. Although not differentiated in the graphical CSM, exposures might occur on the Facility, or outside the Facility in the nearby wetlands or Force Lake. On the Facility, exposure pathways included direct contact with Facility soil and groundwater (i.e., dermal absorption and incidental ingestion), as well as inhalation of chemicals volatilized from soil or groundwater and inhalation of airborne soil particulates during work activities. For non-Facility portions of the Study Area, exposure pathways included direct contact with wetland soil, lake sediment, or lake surface water (i.e., dermal absorption and incidental ingestion) during recreation, as well as indirect exposure through the consumption of fish from Force Lake. The human health CSM identified pathways as complete or incomplete. All complete pathways, except those with low exposure potential, were evaluated quantitatively in the HHRA.

In accordance with EPA guidance (1989), the values used to assess exposure in this HHRA were selected to represent a reasonable maximum exposure (RME). RME is the highest exposure that is reasonably expected to occur at a site and is generally used by EPA to determine whether to conduct a feasibility study for potential remedial actions (EPA 1989). RME scenarios, by definition, likely overestimate exposure for many individuals but were used here to ensure that this baseline HHRA is health-protective. Risks associated with a fifth scenario, the industrial/commercial worker vapor intrusion scenario, were calculated based on a comparison of study area concentrations with published screening levels for the vapor intrusion pathway (EPA 2002c).

The following scenarios were evaluated for the HHRA to assess the exposure of workers to chemicals at the Facility:

- **Industrial (construction/trenching) worker RME scenario:** Current and future onsite workers may be exposed to chemicals in Facility soil via incidental ingestion, dermal absorption, inhalation of airborne soil particulates, and inhalation of volatilized chemicals. Exposure to chemicals in groundwater may occur via dermal absorption and the inhalation of volatilized chemicals.

- **Future outdoor worker RME scenario:** Future outdoor workers may be exposed to chemicals in Facility soil via incidental ingestion, dermal absorption, inhalation of airborne soil particulates, and inhalation of volatilized chemicals.
- **Industrial/commercial worker vapor intrusion scenario:** Current and future onsite workers may be exposed to chemicals in Facility soil or groundwater via the inhalation of chemicals volatilized to indoor air.

The following scenarios were evaluated in the HHRA to assess the exposure of individuals to chemicals in the non-Facility portions of the Study Area:

- **Force Lake recreational user RME scenario:** Individuals who use Force Lake as a recreational area both currently and in the future may be exposed to chemicals in wetland soil or lake sediment via incidental ingestion and dermal absorption (lake and wetland exposure were evaluated separately) and to chemicals in lake surface water through incidental ingestion and dermal absorption.
- **Force Lake fish consumer RME scenario:** Many of the chemicals found at the Study Area are persistent in the environment and can bioaccumulate in the food chain. Thus, individuals who fish recreationally at Force Lake both currently and in the future may be exposed to chemicals in fish tissue via the consumption of fish caught in Force Lake.

In addition, a screening assessment was conducted to evaluate risks based on the exposure of hypothetical future residents to chemicals. In this screening assessment, exposure to chemicals in Facility and wetland soil was assumed to occur via dermal absorption, incidental ingestion, and inhalation of airborne soil particulates. Exposure to chemicals in groundwater was assumed to occur as a result of household use of groundwater. The evaluation was included at the request of EPA (Bridgewater et al. 2008b; Windward and Bridgewater 2008a, b), despite the current and expected future land use of the Study Area, which does not include residential use or development. As stated in the Remedial Investigation/Feasibility Study (RI/FS) work plan (Bridgewater et al. 2008b), the zoning and comprehensive plan designations for the Study Area indicate that the current and likely future use of the Facility is industrial, particularly given its Industrial Sanctuary designation, and the current and likely future use of the wetland area is open space.

In the first step of the exposure assessment, a conservative risk-based screen was performed in accordance with EPA guidance to identify the media-specific COPCs to be evaluated for each scenario. The next step involved the estimation of the potential exposure of people to COPCs for each scenario. Exposures were calculated using concentration data for each COPC and health-protective assumptions.

Exposure point concentrations (EPCs) are the concentrations of COPCs in soil, groundwater, lake sediment, lake surface water, or fish tissue. These EPCs were then used in the exposure equations to calculate COPC intake or exposure. The EPC was either the maximum concentration or the upper confidence limit on the mean concentration² of a COPC and is intended to represent a long-term exposure concentration. In some cases, the EPC was set equal to one-half the maximum reporting limit if this value was higher than the maximum detected concentration or if there were no detected concentrations of the COPC. EPCs for the direct exposure scenarios (i.e., worker and recreation scenarios) were calculated for the area over which the exposure could potentially occur. Literature biota-sediment accumulation factors (BSAFs) were used along with Force Lake sediment concentrations to estimate the fish tissue EPCs.

ES.3 Toxicity Assessment

EPA toxicity values were identified for all COPCs. Toxicity values included slope factors (SFs) or inhalation unit risk factors used to evaluate carcinogenic risks, or reference doses [RfDs] or reference concentrations [RfCs] to estimate the potential for effects other than cancer. Carcinogenic toxicity values (i.e., SFs and inhalation unit risk factors) provide a health-protective means to assess risks because they represent upper bound estimates of carcinogenic potency. Similarly, non-cancer toxicity values (i.e., RfDs and RfCs) are health-protective because they are typically based on the most sensitive endpoint for which adequate data are available and include uncertainty factors or extrapolations to account for sensitive sub-populations or other limitations of the toxicity study data on which they were based.

ES.4 Risk Characterization and Uncertainty Analysis

Carcinogenic risks and non-carcinogenic health effects were evaluated separately in the HHRA because of fundamental differences in the mechanisms of these toxic effects. Carcinogenic risk estimates were calculated by multiplying the estimated COPC intake by the SF or inhalation unit risk factor. Cancer risk estimates were compared with EPA's target risk range of 10^{-6} to 10^{-4} established in the National Contingency Plan for Superfund sites (40 CFR 300). For reference, the lifetime risk of developing cancer in the US population is one in two (i.e., 5×10^{-1}) for men and one in three (i.e., 3×10^{-1}) for women (American Cancer Society 2006). A 1×10^{-6} excess cancer risk represents an additional one-in-one-million probability that an individual

² Data management rules for calculating EPCs, as presented in Section B.3.4.3, considered the detection frequency and the number of samples.

may develop cancer through exposure to COPCs at the Study Area when averaged over a 70-year lifetime.

Non-carcinogenic health effects generally do not occur below a certain concentration or critical dose (although it should be noted that carcinogenic effects may occur below this dose for COPCs that have both carcinogenic and non-carcinogenic effects). The potential for non-carcinogenic health effects is represented by the ratio of the estimated intake to the critical dose (known as a reference dose) and is expressed as an HQ. Exposures resulting in HQs less than or equal to 1 are unlikely to result in non-cancer adverse health effects.

HQs were summed across all exposure pathways and endpoints to derive an overall HI. When the overall HI, regardless of endpoint, was greater than 1, endpoint specific HIs were calculated by summing the HQs for COPCs with common toxicological endpoints (e.g., all HQs calculated for the developmental endpoint).

For worker scenarios based on exposure to COPCs at the Facility, the total excess cancer risk estimates for the future outdoor worker RME scenario and the industrial (construction/trenching) worker RME scenario were greater than 1×10^{-6} (2×10^{-5} and 3×10^{-6} , respectively) (Table ES-1). The total excess cancer risk for the industrial/commercial worker vapor intrusion scenario (9×10^{-7}) was less than 1×10^{-6} .

For scenarios evaluating risks associated with COPCs in the non-Facility portions of the Study Area (Force Lake and the wetlands), the total excess cancer risk was greater than 1×10^{-6} for the Force Lake fish consumer RME scenario (2×10^{-5}) and for the Force Lake recreational user RME scenario (1×10^{-5} across all media) (Table ES-1). The COPC-specific HQs and endpoint-specific non-cancer HIs were less than or equal to 1 for all scenarios.

Table ES-1. Summary of Total Excess Cancer Risks and Non-Cancer HQs

Scenario Name	Total Excess Cancer Risk	Overall HI ^a
Industrial (construction/trenching) worker RME scenario (cumulative risk across media)	3×10^{-6}	1
Future outdoor worker RME scenario	2×10^{-5}	0.6
Industrial/commercial worker vapor intrusion scenario	9×10^{-7}	ne ^b
Force Lake recreational user RME scenario (cumulative risk across media)	1×10^{-5}	0.4 ^c
Force Lake fish consumer RME scenario	2×10^{-5}	3 (endpoint-specific HIs were less than or equal to 1) ^{c, d}

^a The overall HI is equal to the sum of HQs for all COPCs across multiple exposure pathways, endpoints, and/or target organs.

^b Risks for this scenario were calculated using the vapor intrusion screening levels, which are based on the more stringent of the cancer or non-cancer risks (i.e., whichever results in lower screening levels). For this scenario, screening levels for all COPCs were based on cancer risks, and thus it was not possible to calculate non-cancer risks.

- ^c The overall HI is based on children 0 to 6 years of age. This HI is higher than HIs for the integrated (i.e., combined) 0-to-30-year age group and for older age groups (i.e., 7 to 16 years and 17 to 30 years), and thus is typically used for risk management decisions.
- ^d The overall HI for this scenario is equal to 3. Because this value is greater than 1, endpoint-specific HIs were calculated per EPA guidance (EPA 1989). No endpoint-specific HIs were greater than 1 (see Section 5.3.5 for details).

COPC – contaminant of potential concern

HI – hazard index

HQ – hazard quotient

ne – not evaluated

RME – reasonable maximum exposure

The screening assessment for hypothetical future residents indicated that total excess cancer risks would likely be greater than the upper end of EPA's target risk range (10^{-4}) and that some chemicals would have an HQ greater than 1 based on the comparison of Study Area concentrations with regional screening levels (EPA 2009i). However, the wetlands are currently zoned as open space, and the Facility and other surrounding areas are currently zoned for industrial use. City of Portland planning documents indicate that these designations are not likely to change in the future, especially given the "Industrial Sanctuary" designation for the property on which the Facility is located and the fact that the non-Facility portions of the Study Area are in a natural resource management planning area established under the City of Portland planning code. Based on this information, and as stated in the RI/FS Work Plan (Bridgewater et al. 2008b), residential development in this area is unlikely.

Based on the risk estimates, arsenic, cPAH TEQ, total PCBs, total DDTs, and TPH-gasoline (aliphatic) were identified as COCs (i.e., COPCs with risks greater than 10^{-6}). Figure ES-1 presents a comparison of risk estimates broken down by COPC for each of the scenarios with risk estimates greater than 1×10^{-6} . All excess cancer risk estimates were within EPA's target risk range of 10^{-6} to 10^{-4} .

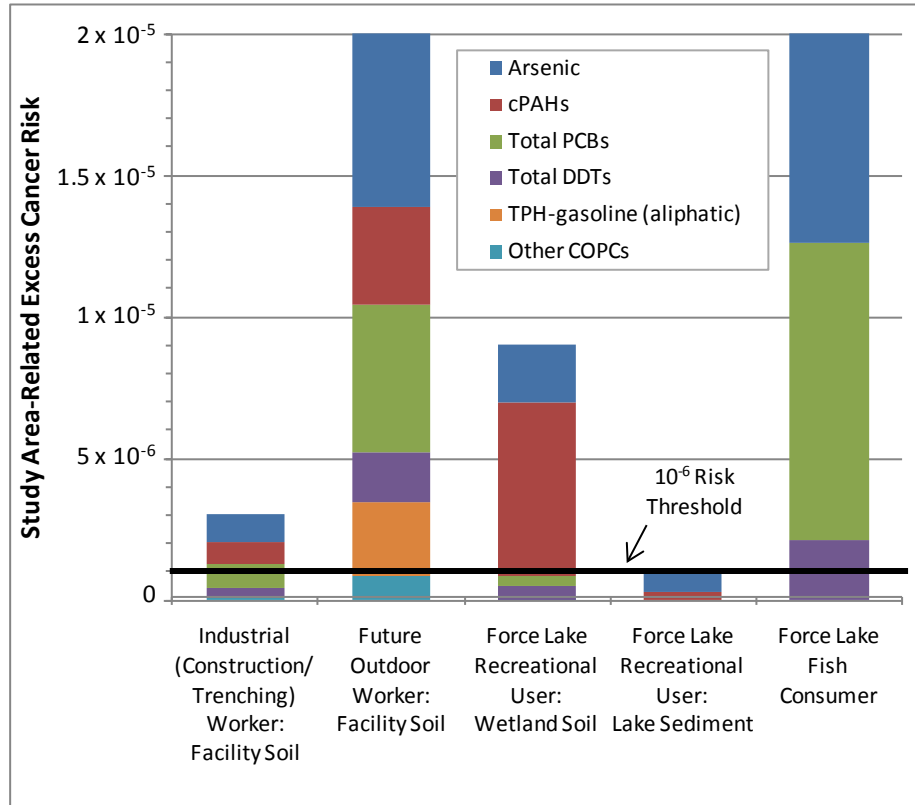


Figure ES-1. Proportion of Total Excess Cancer Risks for Each COC and for other COPCs

For these COCs, background concentrations (for metals) or reference area concentrations³ from local and regional sources (for organic compounds) were used to estimate risks. These risk estimates were compared to Study Area risk estimates. Risk estimates based on background concentrations were similar to those based on Study Area concentrations for arsenic for most scenarios. Risk estimates based on reference area concentrations were generally less than Study Area risk estimates for cPAH TEQ, total PCBs, and total DDTs for all scenarios. No background or reference area concentrations were available for TPH-gasoline.

Uncertainties associated with the risk estimates for each exposure scenario are discussed in this HHRA. Because the scenarios evaluated were either RME scenarios or comparisons to conservative screening levels, the selected exposure assumptions should be protective of the workers at the Facility and the general public. The RME risk estimates, although uncertain, likely overestimate risks for most individuals.

Risk estimates were highest for the Force Lake fish consumer RME scenario and for the future outdoor worker RME scenario. For the Force

³ The term reference area is used instead of background for organic compounds because no specific background concentrations that are representative of anthropogenic background have been selected or approved by EPA. Instead, concentrations from reference areas (i.e., urban areas in the vicinity of the Study Area) are presented for comparison with Study Area concentrations.

Lake fish consumer RME scenario, the main uncertainties included the use of BSAFs rather than actual fish tissue data to estimate fish tissue concentrations, and an estimated fish consumption rate. To ensure that the scenario was health-protective, the values selected for both of these parameters were intended to be conservative. For example, the assumed adult fish consumption rate would require the annual consumption of 5 to 10 times the number of fish observed during the 2009 Force Lake survey (Windward 2009b). If each adult was also assumed to be feeding one child, even more fish would be needed (the annual consumption of 6 to 11 times the number of fish observed during the 2009 Force Lake survey). For the future outdoor worker RME scenario, the main uncertainty was the assumption that the gravel and pavement layers that currently cover the Facility would be removed, which would significantly increase the exposure beyond existing conditions.

Additional analyses presented in this document discuss uncertainties associated with the chemistry data, exposure assumptions, and toxicities of the COPCs. The final risk estimates reflect uncertainties associated with using data and assumptions from multiple sources; the combined effect of those uncertainties on risk estimates cannot be quantified. However, the assessment tended to overestimate risks, consistent with the health-protective nature of risk assessment. Therefore, the baseline characterization of RME risks for the Study Area is considered to be health-protective and sufficient to support risk management decisions.

1.0 INTRODUCTION

1.1 Document Purpose and Scope

On May 31, 2007, the Portland General Electric Company, Bonneville Power Administration, Avista Corporation, NorthWestern Corporation, Union Oil Company of California, and Waste Management Disposal Services of Oregon, Inc. (Voluntary Group for the Harbor Oil Study Area Remedial Investigation/Feasibility Study [RI/FS] [Voluntary Group]) entered into an Administrative Settlement Agreement and Order on Consent for the RI/FS (AOC), Docket No. CERCLA-10-2007-0106, with the US Environmental Protection Agency (EPA) for the Harbor Oil Superfund site (Site) in Portland, Oregon. In accordance with the AOC, the Study Area encompasses the Harbor Oil facility (Facility), an approximately 4.1-acre parcel of land located at 11535 N Force Avenue, the adjacent wetland to the south and west of the main facility, and Force Lake. The AOC statement of work requires that the Voluntary Group prepare an RI that includes a baseline human health risk assessment (HHRA).

This document is the baseline HHRA for the Study Area and presents the characterization of risks for humans at the Study Area, as identified below:

- Section 2.0, Data Evaluation
- Section 3.0, Exposure Assessment
- Section 4.0, Toxicity Assessment
- Section 5.0, Risk Characterization
- Section 6.0, Uncertainty Analysis
- Section 7.0, Conclusions
- Section 8.0, References

The parameters used to assess risks in this HHRA are considered to be conservative regarding exposure and toxicity, as is appropriate for a baseline HHRA, to ensure the adequate protection of humans. This baseline HHRA was prepared by Windward Environmental LLC (Windward) for the Voluntary Group.

1.2 Study Area Location and Facility Description

This section briefly describes the Study Area, as discussed in the RI/FS Work Plan (Bridgewater et al. 2008b), to provide a foundation for the exposure scenarios and pathways discussed in Sections 2.2 and 3.2. The

Study Area is located in north Portland, Multnomah County, Oregon, and includes the Facility, adjacent wetlands to the south and west of the Facility, and Force Lake (Figure 1-1).

According to Coles Environmental Consulting, Inc. (2002), Energy & Material Recovery, Inc. (EMRI), currently operates a waste treatment and processing facility for used oil, oily water, and other wastewater at the Facility. EMRI's office/shop/warehouse building is located on the southeast side of the Facility, near the main entrance along N Force Avenue (Figure 1-2). A portion of this building is also used by Wevco Biodiesel Products LLC for the manufacture of biodiesel. Another portion of the building is occupied by Phoenix Asphalt, an asphalt coating business. Immediately to the west of the building is a card-lock fueling station operated by another tenant of EMRI. Until recently, most of the Facility was unpaved and covered with gravel. However, during the fall of 2011, the majority of the Facility (all areas except for the western-most portion) was paved with asphalt.

Historically, the production of refined fuel oil (RFO) was carried out at a tank farm and used-oil processing area located along the northeast side of the Facility. Wastewater from the RFO process was historically discharged to Tank 12 (located at the northwest end of the tank farm and used oil processing area) for storage and then discharged to Tank 23 for treatment. Tank 23 is no longer used. Currently, the RFO is further processed in a base oil refining plant that was constructed in 2003 (west of the tank farm). Soils excavated during the construction of the base oil refining plant were stockpiled to the northwest of the plant, hereafter referred to as the soil stockpile (Figure 1-2).

A structure in the central area of the Facility was previously used as a tanker truck cleaning operation. The western portion of this structure is currently leased to the asphalt coating business, and the eastern portion is used by EMRI for vehicle and equipment storage.

A soil berm that is approximately 2 to 3 feet high and 5 to 6 feet wide at its base extends along the border of the Facility to the west and south; the berm is intended to prevent stormwater runoff from flowing into the adjacent wetlands (Figure 1-2). As stated in the RI/FS Work Plan (Bridgewater et al. 2008b), the soil berm was constructed shortly after a fire that occurred at the Facility in 1979.

A narrow stretch of natural forested wetlands borders the Facility to the south and west, providing habitat for wetland and terrestrial species (Figure 1-1) and separating the Facility from Force Lake. The lake is 590 to 890 feet in diameter and has a surface area of approximately 12 acres (City of Portland 1997). The depth of the lake ranges from approximately 2 to 6 feet, with an average depth of 2 to 3 feet (Fishman 1989).

The lake is bordered on the east by N Force Avenue and on the south and west by the Heron Lakes Golf Course. There are two known direct discharge points into Force Lake: a catch basin that drains a small area along the east side of N Force Avenue and an underdrain for one of the greens on the golf course (Goodling 2007). The Facility's existing stormwater treatment system does not discharge directly to the lake but

rather drains into the wetlands just south of the Facility. Force Lake drains through two culverts to North Lake, which is northwest of Force Lake and is connected to a series of ditches and other water bodies located on the golf course.



Figure 1-1. Harbor Oil Study Area

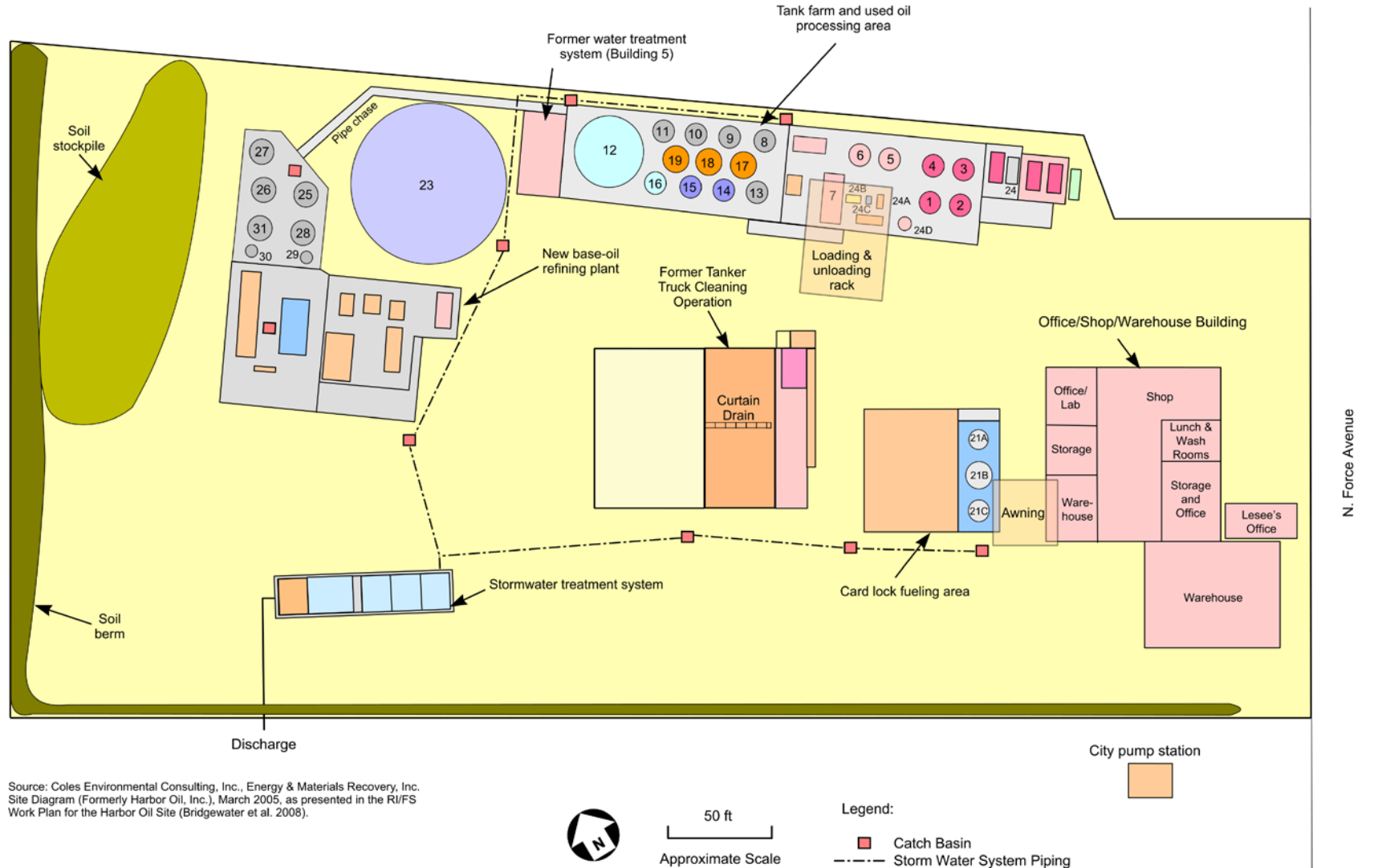


Figure 1-2. Current Facility Features

2.0 DATA EVALUATION

Exposure to chemicals at the Study Area may occur through direct or indirect contact with lake sediment, wetland soil, Facility soil, groundwater, lake surface water, or fish tissue. This section presents a summary of the data available for the Study Area and discusses their use in the baseline HHRA. The following subsections describe data availability (Section 2.1), data reduction (Section 2.2), and the suitability of data for risk assessment purposes (Section 2.3).

2.1 Data Availability and Selection

This section discusses the various data sources that are available for the Study Area and identifies which of these datasets are appropriate for use in this HHRA.

2.1.1 Historical Datasets

This section summarizes the methods and results of a data quality screen that was conducted as part of the data quality objective (DQO) process to determine whether historical data are acceptable for use in the RI, as presented in the risk assessment scoping memorandum (Windward and Bridgewater 2008a). This data quality screen ensured that data used in this HHRA were of adequate quality.

Multiple field investigations at the Facility, adjacent wetland areas, and Force Lake have been conducted since 1988 (Table 2-1). Data from these historical studies were considered for use in the RI dataset if acceptable laboratory methods were used and sufficient analytical and field documentation was available. Data were considered to be unacceptable for use in the RI dataset if field screening methods were used or if insufficient analytical and field documentation was available. Dataset acceptability was evaluated based on the criteria established in the RI/FS Work Plan (Bridgewater et al. 2008b), as discussed in Section 2.1.1.1.

Table 2-1. Datasets Reviewed for Data Quality and Documentation for the Harbor Oil RI

Year	Sampling Event	Data Summary
2001 to 2006	Heron Lakes Golf Course water quality sampling performed by the City of Portland (unpublished)	samples have been collected twice per year since 2001 and analyzed for indicators of nutrient runoff and pesticides (only one year of data was provided to the Voluntary Group)
2003	soil analysis results for the 2003 excavations required for the construction of the EMRI base oil refining plant (Coles 2007)	19 subsurface soil samples were analyzed for TPH-Dx and PCBs
2000	Harbor Oil preliminary assessment/site inspection (Ecology and Environment 2001)	15 surface soil samples, 10 subsurface soil samples, 6 Force Lake sediment samples, ^a 7 groundwater samples, and 1 LNAPL sample were analyzed for TPH-HCID, TPH-G, TPH-Dx, metals, VOCs, SVOCs, PCBs, and pesticides
2000	preliminary risk assessment problem formulation (Coles 2002)	4 surface soil samples, 1 wetland soil sample, and 3 groundwater samples were analyzed for TPH-HCID, TPH-G, TPH-Dx, lead, magnesium, VOCs, SVOCs, and PCBs
1992	Peninsula Drainage District 1 NRMP (City of Portland 1997)	1 Force Lake surface water sample and 1 Force Lake sediment sample were analyzed for TPH (range not reported), metals, VOCs, SVOCs, PCBs, pesticides, and herbicides
1990	Portland Stockyards site investigation and preliminary remediation plan (Golder Associates 1990)	2 surface soil samples, 9 subsurface soil samples, 3 wetland soil samples, and 3 groundwater samples were analyzed for metals
1990	Black & Veatch and RZA stockyards site assessment (RZA 1990, as cited in Golder Associates 1990)	39 soil vapor samples at Merit Truck Stop, Star Oil, Harbor Oil, Rod's Truck Repair, and Stockyards facility were analyzed for VOCs; unspecified testing relating to underground storage tanks was conducted at Merit Truck Stop and the Star Oil facility
1988	Sweet-Edwards/EMCON environmental audit, field investigation, and remedial alternatives assessment (Sweet-Edwards/EMCON 1988, as cited in Golder Associates 1990)	19 shallow borings, 17 surface soil samples, and an unspecified number of groundwater samples collected at Rod's Truck Repair, Harbor Oil, Merit Truck Stop, and Farmers Plant Aid were analyzed for VOCs, PCBs, diesel, and gasoline

^a The six samples designated as Force Lake sediment samples in the 2000 sampling event were characterized as wetland soil samples for the HHRA based on the sampling locations and descriptions. Additionally, one of these six samples was collected on the south side of Force Lake as a background sample. However, because of the proximity of this sample to the golf course, this sample may not represent background concentrations. Thus, only five of these samples were appropriate for use in the HHRA.

EMRI – Energy & Material Recovery, Inc.
 LNAPL – light non-aqueous phase liquid
 NRMP – natural resource management plan
 PCB – polychlorinated biphenyl
 RI – remedial investigation
 RZA – Rittenhouse-Zeman and Associates

SVOC – semivolatile organic compound
 TPH – total petroleum hydrocarbons
 TPH-Dx – total petroleum hydrocarbons-diesel and oil extractable
 TPH-G – total petroleum hydrocarbons-gasoline
 TPH-HCID – total petroleum hydrocarbons-hydrocarbon identification
 VOC – volatile organic compound

2.1.1.1 Criteria for Historical Data Screen

Specific criteria were used to evaluate chemistry data collected during previous (i.e., pre-RI) sampling events to determine their acceptability for use in the RI. All new data collected through the RI process outlined in the RI/FS Work Plan met these criteria through compliance with the methods detailed in the quality assurance project plan (Bridgewater et al. 2008b).

The criteria for chemistry data use in the RI for all purposes were as follows:

- Hard copy or original electronic copy of data report must be available.
- Field coordinates must be available.
- Data must have been collected using acceptable sampling methods.
- Sample depth must be identified.
- Sample type must be clearly identified.
- Analytical methods must be identified and acceptable.
- Quality assurance/quality control (QA/QC) information must be available.
- Data validation qualifiers must be present, or derivable from laboratory qualifiers or QA information and must be applied in a manner consistent with EPA functional guidelines (EPA 1999, 2002e). For non-detected results, detection limits and appropriate qualifiers must be provided.
- Data reports should contain laboratory-generated forms (often called Form Is) with the results for each sample.
- Documentation supporting the dataset, including the analytical raw data, chain-of-custody forms, and sample handling descriptions, should be available for future reference, confirmation, and/or reproducibility by a third party.

Although EPA has not established definitive guidelines specifying the level of data validation required for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPA Order 5360.1 and Office of Solid Waste and Emergency Response (OSWER) Directive 9355.9-01 (EPA 1993) require environmental measurements to be of known quality, verifiable, and defensible. EPA's information quality guidelines (2002b) require that a historical dataset be of known quality and legally defensible and have undergone the same level of scrutiny and review as any other environmental data generated internally or externally by or for EPA to be used for decision-making.

2.1.1.2 Historical Data Screen Results

The results of the data screen are presented in Table 2-2. The data from one sampling event (Ecology and Environment 2001) are considered acceptable for use in the HHRA. Data from seven sampling events did not meet minimum DQOs and were determined to be unsuitable for use in this HHRA. These seven sampling events are listed in Table 2-2 with the rationale for their exclusion.

2.1.2 Data Acceptable for Use in the Baseline HHRA

As described in Section 2.1.1, only one of the eight historical datasets available for the Study Area was acceptable for use in this HHRA. In addition to this historical sampling event, two phases of RI data collection were conducted at the Study Area (the first in April 2008 and the second in April 2009). Table 2-3 presents a summary of the chemistry data available from these three sampling events. In addition, Figure 2-1 shows the locations of these samples.

Details on all of the specific samples used in the HHRA (across all three sampling events listed above) are summarized in Table 2-4.

Table 2-2. Results of Data Screen of Historical Datasets

Sampling Year	Sampling Event	Available Documentation	Acceptability for All Uses in the RI	Rationale for Exclusion
2001 to 2006	Heron Lakes Golf Course water quality sampling conducted by the City of Portland 2006 (unpublished)	laboratory reports provided by J Goodling to S Brown	unacceptable	Minimum DQOs were not met; data report and supporting documentation were not available.
2003	soil analysis results for the 2003 excavations required for the construction of the EMRI base oil refining plant (Coles 2007)	field notes, chain-of-custody forms, and laboratory report forms	unacceptable	Minimum DQOs were not met; data report and data validation report were not available.
2000	Harbor Oil preliminary assessment/site inspection (Ecology and Environment 2001)	sampling and quality assurance plan, data report, data validation memoranda, laboratory report forms; raw data and chain-of-custody forms on file with EPA, Ecology and Environment, Inc., and/or MEL	acceptable	Dataset was acceptable.
2000	preliminary risk assessment problem formulation (Coles 2002)	laboratory report forms; some QA/QC information; sampling methods, sample depths, and coordinates not provided	unacceptable	Minimum DQOs were not met; data were unvalidated; raw data were unavailable; uncertainty exists regarding sampling locations, methods, and depths.
1992	Peninsula Drainage District 1 NRMP (City of Portland 1997)	incomplete data report; copies of laboratory report forms and QA/QC information are not available; sampling methods, locations, and depths not provided	unacceptable	Minimum DQOs were not met; laboratory report forms and QA/QC information were unavailable; uncertainty exists regarding sampling locations, methods, and depths.
1990	Portland Stockyards site investigation and preliminary remediation plan (Golder Associates 1990)	data report	unacceptable	Minimum DQOs were not met; laboratory report forms and QA/QC information were unavailable.
1990	Black & Veatch and RZA stockyards site assessment (RZA 1990, as cited in Golder Associates 1990)	incomplete documentation and uncertain data quality	unacceptable	Minimum DQOs were not met; data report and supportive documentation were not available.
1988	Sweet-Edwards/EMCON environmental audit, field investigation, and remedial alternatives assessment (Sweet-Edwards/EMCON 1988, as cited in Golder Associates 1990)	incomplete documentation and uncertain data quality	unacceptable	Minimum DQOs were not met; data report and supportive documentation were not available.

DQO – data quality objective

EMRI – Energy & Material Recovery, Inc.

EPA – US Environmental Protection Agency

MEL – Manchester Environmental Laboratory

NRMP – natural resource management plan

QA/QC – quality assurance/quality control

RI – remedial investigation

RZA – Rittenhouse-Zeman and Associates

SVOC – semivolatile organic compound

VOC – volatile organic compound

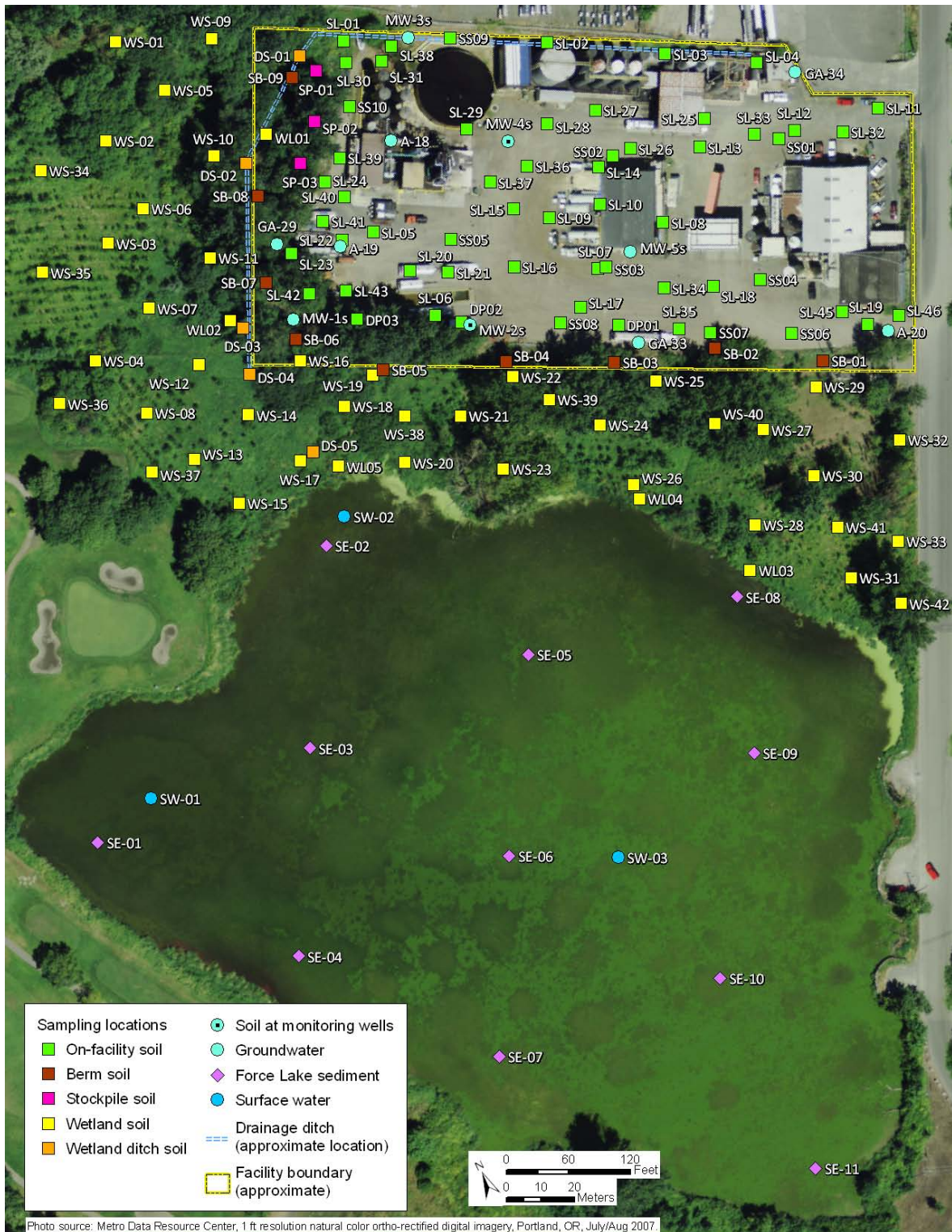


Figure 2-1. Sampling Locations for Data Used in the Baseline HHRA

Table 2-3. Summary of Data Used in the Baseline HHRA by Sampling Event

Sampling Event	Year	Media	Number of Locations ^a	Source	Analytes
Preliminary assessment/site inspection	2000	facility soil	13	Ecology and Environment (2001)	metals, PAHs, phthalates, other SVOCs, PCBs, pesticides, VOCs, petroleum
		groundwater	7		metals, PAHs, phthalates, other SVOCs, PCBs, pesticides, VOCs, petroleum
		wetland soil	5 ^b		metals, PAHs, phthalates, other SVOCs, PCBs, pesticides, VOCs, petroleum, conventionals
RI Phase 1 sampling	2008	facility soil	34	Windward et al. (2008)	metals, PAHs, phthalates, SVOCs, PCBs, pesticides, VOCs, petroleum, conventionals
		soil stockpile	3		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum, conventionals
		soil berm	9		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum, conventionals
		groundwater	16		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum, conventionals
		wetland soil	33		metals, PAHs, phthalates, other SVOCs, PCBs, pesticides, VOCs, petroleum, conventionals
		lake sediment	11		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum, grain size, conventionals
		lake surface water	3		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum
RI Phase 2 sampling	2009	facility soil	15	Harbor Oil RI database	metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum, conventionals
		groundwater	11		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum, conventionals
		wetland soil	13		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, petroleum, conventionals
		lake sediment	3		metals, PAHs, SVOCs (excluding phthalates), PCBs, pesticides, VOCs, petroleum, conventionals

^a This table presents the number of locations, not samples, available for use in the HHRA. See Table 2-4 for the sample count by scenario.

^b A total of six wetland soil samples were collected during this event, but one of these samples was collected on the south side of Force Lake as a background sample. This sample was excluded from the HHRA database.

HHRA – human health risk assessment

PCB – polychlorinated biphenyl

SVOC – semi-volatile organic compound

PAH – polycyclic aromatic hydrocarbon

RI – remedial investigation

VOC – volatile organic compound

Table 2-4. Summary of Data Used in the Baseline HHRA

Media	Sample Description	Sample Depth Category	Range of Sample Depth	No. of Samples
Industrial (construction/trenching) worker RME scenario	Facility soil	surface	0 to 60 inches	57
		intermediate and deep	24 to 102 inches	34
	wetland ditch soil	surface	0 to 6 inches	7
		intermediate and deep	6 to 36 inches	6
	soil berm	na	6 to 24 inches	9
	soil stockpile	na	6 to 72 inches	3
	groundwater	shallow	0 to 20 feet	18
Future outdoor worker RME scenario	Facility soil	surface	0 to 60 inches	57
	wetland ditch soil	surface	0 to 6 inches	7
	soil berm	na	6 to 24 inches	9
Industrial/commercial vapor intrusion worker scenario (current)	groundwater	shallow	0 to 20 feet	4
Industrial/commercial vapor intrusion worker scenario (hypothetical)	groundwater	shallow	0 to 20 feet	22
Force Lake recreational user RME scenario	wetland soil	surface	0 to 6 inches	52
	soil berm	na	6 to 24 inches	9
	Force Lake sediment	shallow	0 to 4 inches	11
	Force Lake surface water	surface	12 inches	3
Force Lake fish consumer RME scenario	Force Lake sediment	shallow	0 to 4 inches	11

HHRA – human health risk assessment

na – not applicable

RME – reasonable maximum exposure

In addition, as a part of the RI Phase 2 sampling, a survey of the fish population in Force Lake was conducted to obtain information on the types of fish present in the lake and estimate the abundance and sizes of these fish. This survey was necessary to provide additional information for use in the fish consumer scenario developed as part of this baseline HHRA (Section 3.3.3).

2.2 Data Reduction

Data reduction refers to computational methods used to aggregate the data for use in the HHRA. The most significant use of aggregated data was for the calculation of exposure point concentrations (EPCs). The methods used to calculate EPCs are described in detail in the exposure assessment (Section 3.3.4).

Additional procedures related to averaging, selection of the best data points when multiple data were available, selection of significant figures and rounding procedures, and calculating totals for chemical groupings (i.e., polychlorinated biphenyls [PCBs], polycyclic aromatic hydrocarbons [PAHs], dichlorodiphenyltrichloroethane [DDT], chlordane, and total petroleum hydrocarbons [TPH]) are described below.

2.2.1 Duplicate or Replicate Samples

Chemical concentrations obtained from the analysis of laboratory duplicate and triplicate samples (two or more analyses of the same sample) were compared to the results of the original sample. A single value that represented the original sample and laboratory duplicate and triplicate samples were selected. This final result could be verified through the use of the original laboratory reports (i.e., Form Is). Final result selection rules were dependent on whether the individual results were detected. If all concentrations were detected for a single chemical, the maximum detected concentration was selected as the final result. If all results for a given parameter were not detected, the minimum RL was selected for the final result. If the concentrations were a mixture of detected concentrations and RLs, the maximum detected concentration was selected as the final result, regardless of whether the RLs were higher or lower than the detected concentration.

Exceptions to these rules were made for some specific conventional parameters (i.e., grain size, total organic carbon, total solids). For these parameters, the result from the original sample was selected as the final reported result.

2.2.2 Selection of Best Results

In some instances, the laboratory generated more than one result for a chemical for a given sample. Multiple results could have occurred for several reasons, including: 1) the original result does not meet the laboratory's internal QC guidelines and a reanalysis is performed, 2) the original result does not meet other project DQOs, such as a sufficiently low RL, and a reanalysis is performed, or 3) a chemical is analyzed by more than one method for a given sample. In each case, a single best result was selected for use, as described below:

- Detected and not qualified, then the result from the lowest dilution was selected, unless multiple results from the same dilution were available, in which case, the result with the highest concentration was selected.

- A combination of estimated and unqualified detected results, then the unqualified result was selected. This situation most commonly occurred when the original result was outside of the calibration range, thus requiring a dilution.
- All estimated, then the “best result” was selected using best professional judgment in consideration of the rationale for qualification. For example, a result qualified based on laboratory duplicate results outside of QC objectives for precision was preferred to a qualified result that was outside the calibration range.
- A combination of detected and undetected results, then the detected result was selected. If there was more than one detected result, the applicable rules for multiple results (as discussed above) were followed.
- All undetected results, then the lowest RL was selected.

2.2.3 Significant Figures and Rounding

Analytical laboratories reported results with various numbers of significant figures depending on the laboratory’s standard operating procedures, the instrument, chemical, and the reported concentration relative to the RL. The reported (or assessed) precision of each result was explicitly stored in the project database by recording the number of significant figures. Tracking of significant figures is important when calculating averages and performing other data summaries. When a calculation involves addition, such as totaling PCBs, the calculation could only be as precise as the least precise number that went into the calculation. For example:

$210 + 19 = 229$ would be reported as 230 because although 19 is reported to 2 significant digits, and the trailing zero in the number 210 is not significant.

When a calculation involved multiplication or division, the final result was rounded at the end of the calculation to reflect the value used in the calculation with the fewest significant figures. For example:

$59.9 \times 1.2 = 71.88$ would be reported as 72 because there are two significant figures in the number 1.2.

When rounding, if the number following the last significant figure was less than 5, the digit was left unchanged. If the number following the last significant figure was equal to or greater than 5, the digit was increased by 1. All calculated means and medians were reported to two significant figures.

2.2.4 Calculating Totals

Total PCBs, total DDTs, total PAHs, and total chlordane were calculated by summing the detected values for the individual components available for each sample. For individual samples in which none of the individual components was detected, the total value was given a value equal to the

highest RL⁴ of an individual component and assigned the same qualifier (U or UJ), indicating an undetected result. For individual samples that had both detected and undetected results for individual components, only the detected concentrations were summed, and the RLs for the undetected components were ignored. Concentrations for the analyte sums were calculated as follows:

- **Total PCBs** were calculated using only detected values for seven Aroclor mixtures.⁵ For individual samples in which none of the seven Aroclor mixtures was detected, total PCBs were reported as equal to the highest RL of the seven Aroclors and assigned a U-qualifier.
- **Total DDTs** were calculated using only detected values for the DDT isomers: 2,4'-dichlorodiphenyldichloroethane (DDD); 4,4'-DDD; 2,4'-dichlorodiphenyldichloroethylene (DDE); 4,4'-DDE; 2,4'-DDT and 4,4'-DDT. For individual samples in which none of the isomers was detected, total DDTs were given a value equal to the highest RL of the isomers and assigned a U-qualifier, indicating the lack of detected concentrations.
- **Total chlordane** was calculated using only detected values for the following compounds: alpha-chlordane, gamma-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor. For individual samples in which none of these compounds was detected, total chlordane was given a value equal to the highest RL of the compounds listed above and assigned a U-qualifier, indicating the lack of detected concentrations.
- **Carcinogenic polycyclic aromatic hydrocarbons (cPAHs)** were summed based on potency equivalency factors (Table 2-5). This sum is considered a toxic equivalent (TEQ) because the concentrations of the individual cPAHs are scaled based on their potency relative to that of benzo(a)pyrene (the most toxic cPAH). The cPAH TEQ for each sample was calculated by summing the product of the concentration of each individual compound and its specific potency equivalency factor. Compounds that were not detected for a given sample were assigned a value equal to one-half the sample-specific RL for use in the TEQ equation.

⁴ It should be noted that the treatment of RLs in calculating totals is different than the treatment of RLs for duplicate or replicate samples (Section 2.2.1) or in the selection of best results (Section 2.2.2). The highest RL is used in calculated totals to be conservative; whereas the lowest RL is used in data reduction in order to select the most precise analytical RL reported.

⁵ Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Table 2-5. Potency Equivalency Factors for cPAHs

Compound	Potency Equivalency Factors ^a
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenzo(a,h)anthracene	0.4
Indeno(1,2,3-cd)pyrene	0.1

^a Potency equivalency factors for cPAHs were developed by Cal EPA, Office of Environmental Health Hazard Assessment, and were presented in Appendix B (Table 8) of Cal EPA's air toxics hot spots risk assessment guidance (California EPA 2009). Potency equivalency factors for other PAHs are also available; those presented here are for PAHs analyzed in Harbor Oil samples.

Cal EPA – California Environmental Protection Agency

cPAH – carcinogenic polycyclic aromatic hydrocarbon

2.2.5 Aliphatic TPH

For risk assessment purposes, EPA's recent TPH guidance (2009f) recommends assessing TPH as six fractions: the aliphatic and aromatic fractions of low-, medium-, and high-carbon content. For the Study Area, TPH were analyzed as three fractions – gasoline, diesel, and motor oil ranges – which roughly correspond to the low-, medium-, and high-carbon ranges, respectively. Therefore, in consultation with EPA (Windward 2010), the following methodology was used to ensure that both aliphatic and aromatic TPH fractions were addressed in this HHRA:

- Aliphatic TPH fractions:** The aliphatic TPH fraction concentrations were estimated by assuming a percentage of each fraction (i.e., gasoline, diesel, and motor oil) was aliphatic. Based on information presented in ATSDR (1999), 85% of each fraction was assumed to be aliphatic (the midpoint of the range of 80 to 90% presented in ATSDR for various petroleum products). The estimated aliphatic TPH fractions were treated the same as all other chemicals in this HHRA (i.e., the aliphatic TPH fractions were compared with screening levels; and if concentrations were greater than screening levels, they were selected as COPCs for further evaluation in this HHRA).
- Aromatic TPH fractions:** Aromatic TPH fractions are predominantly composed of various VOCs and PAHs (e.g., benzene, naphthalene, and toluene), which were evaluated as individual components in this HHRA. Risks for the aromatic fraction were not directly calculated to avoid double-counting risks from these chemicals.

2.3 Suitability of Data for Risk Assessment

There are several factors to consider in assessing the suitability of environmental data for risk assessments (EPA 1989, 1992b). Of primary importance is the degree to which the data adequately represent expected human exposures in the Study Area. Also important to consider are the data quality criteria goals and the source, documentation, analytical methods, RLs, and level of review associated with the data. Because data from several investigations were available for the Study Area, these factors were evaluated for each dataset to determine whether it was reasonable to combine all data for use in this baseline HHRA. These suitability determinations were performed in consultation with EPA.

2.3.1 Representativeness to Study Area Concentrations

The majority of data available for use in this HHRA were collected during the two phases of RI sampling. Because the sampling plan for the RI was designed to accommodate the risk assessments and to characterize the nature and extent of chemical concentrations at the site, the distribution of samples across the site adequately reflects the site-related concentrations. For example, the density of Facility soil and wetland sampling locations was high in order to more accurately characterize the higher variability in chemical concentrations in these areas. The density of lake sediment and surface water samples is lower, reflecting the more homogeneous nature of the chemical concentrations in Force Lake. In addition, to ensure complete characterization of the chemical concentrations at the Study Area, surface and subsurface samples were collected at various locations.

Groundwater samples were collected in summer 2000, spring 2008, and spring 2009. The inclusion of data from multiple years and seasons makes it more likely that temporal variability in chemical concentrations in groundwater has been captured, as compared with reliance on data from only a single monitoring event.

It should also be noted that surface sediment samples were collected from North Lake but are not included in this HHRA. These samples were collected to determine the extent of chemical migration from Force Lake to North Lake. As presented in the preliminary site characterization report (Windward et al. 2008; Section 6.5.2), an analysis of these samples indicated that the migration of chemicals from Force Lake to North Lake is limited. Thus, the samples collected from North Lake are not representative of concentrations related to the Facility and are not included in the HHRA. The inclusion of these samples in the lake exposure dataset would have reduced exposure concentrations because chemical concentrations are lower in North Lake than in Force Lake.

2.3.2 Representativeness to Expected Human Exposure

People may come in contact with chemicals at the Study Area through various activities, including working at the Facility and participating in recreational activities in and around Force Lake. A more detailed description of these activities is provided in Section 3.1. The overall distribution of samples reflects the expected human exposure from activities at the Study Area.

In addition, the collection of both surface and subsurface soil samples allows for a more complete characterization of risks for individuals who might contact deeper material.

2.3.3 Quality Assurance/Quality Control Results

As discussed in Section 2.1.1.1, the dataset used in the HHRA had to meet specific criteria. One of these requirements was that all datasets had to be validated by the original authors of the individual studies or by outside third parties. No additional data validation is planned for this HHRA, but the data used in the HHRA have been sufficiently validated. Any data qualified as unusable by the data validators were not used in this HHRA.

2.3.4 Other Factors

This section discusses several additional factors that were important in the determination of data suitability for this HHRA.

2.3.4.1 Documentation of Field and Laboratory Practices

Documenting field and laboratory procedures allows for the assessment of the impact of any deviation from these procedures on data usability. For data to be considered for use in this HHRA, information regarding the sampling method, sample depth, sample type, and sampling location had to be available, as discussed in Section 2.1.1.1. The determination that a dataset was usable for this HHRA indicated that a thorough review of the documentation provided (e.g., method descriptions, QC results) for the various studies did not reveal any issues that would adversely affect the usability of the data for risk assessment purposes. Data collected by the Voluntary Group followed field and laboratory procedures that were approved by EPA and met the criteria outlined above.

2.3.4.2 Analytical Data Review

The level of analytical data review can also affect data usability. All data used in this HHRA were subjected to a thorough data reduction and validation process. All datasets considered suitable for use in this HHRA had sufficient documentation to complete this review.

2.3.4.3 Analytical Methods

Analytical methods selected for use in analyzing the samples collected during the two phases of the RI sampling effort were approved by EPA in advance of sampling. For the samples collected as part of the RI sampling effort, the analytical methods are described in the quality assurance project plan (Bridgewater et al. 2008a) and were summarized in the preliminary site characterization report (Windward et al. 2008). For samples collected as part of the Harbor Oil preliminary assessment/site inspection (Ecology and Environment 2001), the methods were adequately described in the sampling documentation to determine that they were acceptable.

3.0 EXPOSURE ASSESSMENT

This section describes the scenarios in which people may be exposed to chemicals present at the Study Area and provides the methods that will be used to assess the risks associated with these scenarios. Section 3.1 presents the conceptual site model (CSM) for the Study Area, Section 3.2 presents the screening of the data for the selection of contaminants of potential concern (COPCs), Section 3.3 describes the exposure parameters for each scenario and the calculation of the chronic daily intake (CDI), Section 3.4 presents the CDI rates for each COPC.

3.1 Conceptual Site Model

The CSM is a representation of chemical sources, transport mechanisms, exposure pathways, exposure routes, and potentially exposed populations. It provides the basis for developing exposure scenarios to be evaluated in the exposure assessment component of the HHRA.

In accordance with EPA guidance (1989), the values used to assess exposure in this HHRA were selected to represent a reasonable maximum exposure (RME), which is the highest exposure that is reasonably expected to occur at a site. RME by definition likely overestimates exposure for most individuals but was used here to ensure that this baseline HHRA is sufficiently health-protective. Risks associated with a fifth scenario, the industrial/commercial worker vapor intrusion scenario, were calculated using the default exposure parameters used to develop the published vapor intrusion screening levels (EPA 2002c), and thus site-specific exposure parameters were not needed.

These five exposure scenarios were developed to represent potentially exposed populations. Each exposure scenario involved at least one potential pathway of exposure to contaminated media and a potential exposure route through which chemicals can enter the body of an exposed individual. However it should be noted that the importance of some pathway/route combinations is minor or incomplete for some scenarios.

The five scenarios presented are not mutually exclusive; an individual could be exposed through the activities included in more than one scenario. Therefore, several of the scenarios are evaluated cumulatively in the risk characterization summary. For example, individuals exposed to lake sediment, wetland soil, and lake surface water through recreational activities could also consume fish caught in Force Lake.

The five scenarios presented in the CSM for this baseline HHRA are briefly described below:

- **Industrial (construction/trenching) worker RME scenario:** Current and future onsite workers may be exposed to chemicals in Facility soil via incidental ingestion, dermal absorption, inhalation of airborne soil particulates, and inhalation of volatilized contaminants. Exposure to chemicals in groundwater may occur via dermal absorption and the inhalation of volatilized chemicals.
- **Future outdoor worker RME scenario:** Future outdoor workers may be exposed to chemicals in Facility soil via incidental ingestion, dermal absorption, inhalation of airborne soil particulates, and inhalation of volatilized chemicals.
- **Industrial/commercial worker vapor intrusion scenario:** Current and future onsite workers may be exposed to chemicals in Facility soil or groundwater via the inhalation of chemicals volatilized to indoor air.
- **Force Lake recreational user RME scenario:** Individuals who use Force Lake as a recreational area both currently and in the future may be exposed to chemicals in wetland soil or lake sediment via incidental ingestion and dermal absorption (lake and wetland exposure were evaluated separately) and to chemicals in lake surface water through incidental ingestion and dermal absorption.
- **Force Lake fish consumer RME scenario:** Many of the chemicals found at Harbor Oil are persistent in the environment and can bioaccumulate in the food chain. Thus, individuals who fish recreationally at Force Lake both currently and in the future may be exposed to chemicals in fish tissue via the consumption of fish caught in Force Lake.

In addition, at the request of EPA, a screening assessment was conducted to evaluate risks associated with hypothetical future residential exposure (see Attachment 1). In this screening assessment, exposure to chemicals in Facility and wetland soil was assumed to occur via dermal absorption, incidental ingestion, and the inhalation of airborne soil particulates. Exposure to chemicals in groundwater was assumed to occur as a result of household use of groundwater as tap water. Consistent with past agreements with EPA (Bridgewater et al. 2008b; Windward and Bridgewater 2008a, b), this screening level assessment was included in this HHRA even though the current and expected future land uses are industrial for the Facility and open space for the wetlands and Force Lake.

Figure 3-1 presents the CSM for risk to human health from the Study Area. The preliminary CSM was presented in the RI/FS Work Plan (Bridgewater et al. 2008b). The five scenarios listed above were developed to characterize risk from exposure to chemicals at the Study Area. The following subsections summarize the scenarios, provide

information on the exposure pathways/routes considered for each scenario, and discuss which data were used to estimate exposures.

Each scenario shown in Figure 3-1 and Table 3-1 is discussed qualitatively in the subsections that follow. The exposure parameters for each scenario are presented in Section 3.3.2.

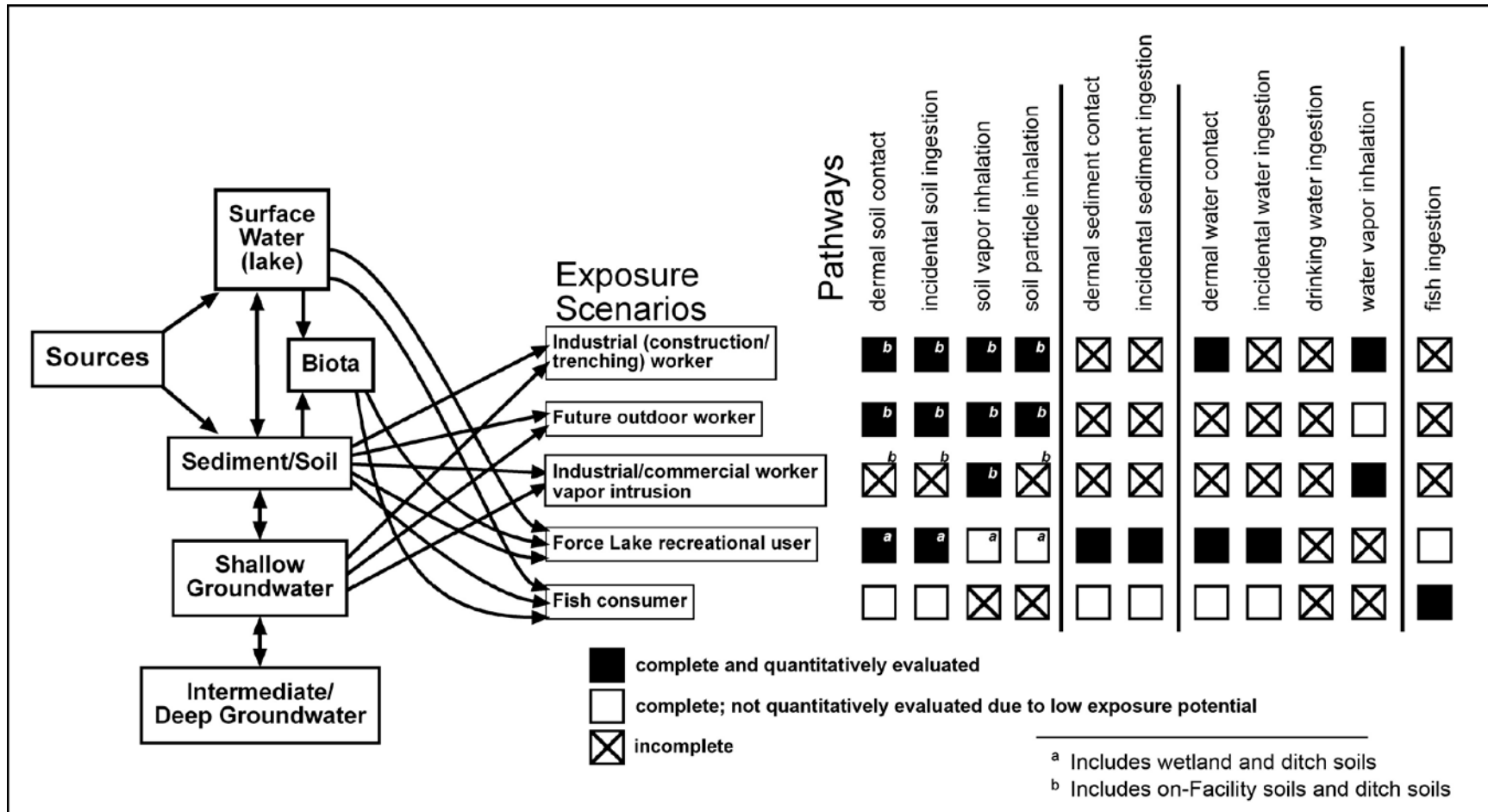


Figure 3-1. Human Health CSM

Table 3-1. Rationale for the Selection or Exclusion of Exposure Pathways

Exposure Scenario	Exposure Point	Exposure Timeframe	Exposure Medium	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Industrial (construction/trenching) worker RME scenario	Harbor Oil Facility	current and future	Facility soil	worker	adult	dermal	quantitative	Represents the most likely direct contact pathway for soil exposure.
						ingestion ^a	quantitative	
						inhalation	quantitative	Inhalation of airborne soil particulates and chemicals volatilized from soil are possible.
			ground-water	worker	adult	dermal	quantitative	Dermal contact with groundwater is possible.
						ingestion ^a	qualitative	Exposure typically not quantified because of low exposure potential and high level of uncertainty (DEQ 2003).
						inhalation	quantitative	Inhalation of chemicals volatilized from water is possible.
Future outdoor worker RME scenario	Harbor Oil Facility	future	Facility soil	worker	adult	dermal	quantitative	Represents the most likely direct contact pathway for soil exposure.
						ingestion ^a	quantitative	
						inhalation	qualitative	Inhalation of airborne soil particulates and inhalation of chemicals volatilized from soil are possible.
			ground-water	worker	adult	inhalation	qualitative	Inhalation of chemicals volatilized from water is insignificant compared with direct contact with soil.
Industrial/commercial worker scenario	Harbor Oil Facility	current and future	Facility soil	worker	adult	inhalation	quantitative	Exposure through the inhalation of soil particulates or inhalation of chemicals volatilized from water that have intruded into buildings is possible.
			ground-water	worker	adult	inhalation	quantitative	

Table 3-1. Rationale for the Selection or Exclusion of Exposure Pathways

Exposure Scenario	Exposure Point	Exposure Timeframe	Exposure Medium	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Force Lake recreational user RME scenario	Harbor Oil Study Area (excluding the Facility)	current and future	wetland soil	visitor	adult/ child	dermal	quantitative	Represents the most likely direct contact pathway for soil exposure.
						ingestion ^a	quantitative	
			inhalation			qualitative	Inhalation of soil particulates or inhalation of chemicals volatilized from soil is insignificant compared with direct contact with soil.	
			dermal			quantitative	Represents the most likely direct contact pathway for sediment exposure.	
			ingestion ^a			quantitative		
			dermal			quantitative	Represents the most likely direct contact pathway for water exposure.	
			ingestion ^a			quantitative		
Force Lake fish consumer RME scenario	Force Lake	current and future	fish tissue	visitor	adult/ child	ingestion	quantitative	Although available data suggest fish consumption rates from Force Lake are low, it is possible for individuals to catch fish in Force Lake.

^a Incidental ingestion associated with dermal contact.

DEQ – Oregon Department of Environmental Quality

RME – reasonable maximum exposure

3.1.1 Industrial (Construction/Trenching) Worker RME Scenario

The construction/trenching industrial worker RME scenario was evaluated to estimate risks to workers involved in construction or other intrusive work conducted outdoors at the Facility, such as digging shallow trenches (assumed to be no more than waist deep) or excavating dirt to prepare for new buildings at the Facility. This type of work is not likely to occur at the Facility for an extended duration. Thus, the exposure assumptions were developed to represent exposure to soil and groundwater during work conducted over a limited time period (1 year). To ensure that this scenario is sufficiently conservative, health-protective parameters were selected from DEQ's *Guidance for Conduct of Deterministic Human Health Risk Assessments* (1998), DEQ's *Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites* (2003), and EPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (2002d).

These workers could be exposed through the following exposure routes:

- **Facility surface and subsurface soils:** dermal absorption, incidental ingestion, inhalation of soil particulates, and inhalation of chemicals volatilized from soil
- **Groundwater:** dermal absorption and inhalation of chemicals volatilized from water

Exposure to Facility soil was assessed using all surface soil samples and subsurface soil samples (to a depth of 4 to 6 feet below ground surface) collected at the Facility, including soil stockpile, soil berm, and ditch soil samples as discussed in the RI/FS Work Plan (Bridgewater et al. 2008b) and risk assessment scoping memorandum (Windward and Bridgewater 2008a). Exposure to groundwater was assessed using all shallow groundwater samples. The saturated zone for shallow groundwater at the Facility is close to the surface (1 to 6 ft bgs), and thus it is likely that there would be a small amount of standing water at the bottom of the trench in some locations. In addition, risks from inhalation exposures were assessed for chemicals in groundwater and soil. Concentrations associated with volatilized chemicals were modeled as described in Section 3.3.1 and in Attachment 4.

Exposure pathways that were considered incomplete or complete and insignificant for the industrial (construction/trenching) worker RME scenario are discussed below, along with rationale regarding the exclusion of these pathways:

- **Dermal sediment contact or incidental sediment ingestion:** Workers at the Facility were not expected to come into contact with lake sediment.
- **Incidental water ingestion:** While workers may come into contact with groundwater, the incidental ingestion of groundwater was considered incomplete because of the low exposure potential and

a high level of uncertainty regarding risk calculations for this pathway (see Table 3-1).

- **Drinking water ingestion:** Groundwater at the Facility is not a source of drinking water.
- **Fish ingestion:** Workers at the Facility were not expected to consume fish from Force Lake.

3.1.2 Future Outdoor Worker RME Scenario

The future outdoor worker RME scenario was evaluated to assess risks to outdoor workers in the event that the surficial gravel fill material and pavement that currently covers most of the Facility is removed. These workers are assumed to be performing routine activities at the Facility (e.g., walking between operations); these activities would not involve digging or construction work. Exposure to chemicals could occur through dermal absorption, incidental ingestion, inhalation of airborne soil particulates, and inhalation of volatilized chemicals in Facility soil. The exposure parameters for this scenario were based on the occupational worker described in DEQ's *Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites* (2003) and the outdoor worker described in EPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (2002d).

A current outdoor worker scenario was not assessed because the exposure of current Facility workers is expected to be lower than the exposure for the future outdoor worker RME scenario because gravel fill material and/or pavement that currently covers most of the Facility. In addition, current Facility workers spend most of their time working indoors in the base-oil plant or sitting in tanker trucks, although they also spend some time outdoors walking between operations.

Future outdoor worker exposure to Facility soil was assessed using all surface soil samples collected at the Facility, including soil stockpile, soil berm, and ditch soil samples as discussed in the RI/FS Work Plan (Bridgewater et al. 2008b) and risk assessment scoping memorandum (Windward and Bridgewater 2008a).

Exposure pathways that were considered incomplete or complete and insignificant for the future outdoor worker RME scenario are listed below, along with rationale regarding the exclusion of these pathways:

- **Dermal sediment contact or incidental sediment ingestion:** Workers at the Facility were not expected to come into contact with lake sediment.
- **Dermal water contact or incidental water ingestion:** Exposure to groundwater was not expected based on the daily activities of workers at the Facility.
- **Drinking water ingestion:** Groundwater at the Facility is not a source of drinking water.

- **Inhalation of chemicals volatilized from water:** Risks associated with inhalation were not assessed because of the low exposure potential and because risks from inhalation were expected to be insignificant compared to risks from dermal contact and incidental ingestion of soil.
- **Fish ingestion:** Workers at the Facility were not expected to consume fish from Force Lake.

3.1.3 Industrial/Commercial Worker Vapor Intrusion Scenario

The industrial/commercial worker vapor intrusion scenario was evaluated to estimate risks to workers associated with the intrusion of vapors into buildings at the Facility. These workers were assumed to be performing routine activities inside buildings at the Facility, such as administrative tasks or other office work. Workers involved in everyday activities are not likely to be in contact with potentially contaminated soils because of the layer of packed gravel (approximately 12 inches thick in most locations) and pavement that cover the Facility. Thus, potential exposure for typical workers is largely via indoor exposure, and exposure to contaminants in soil via direct contact is expected to be low relative to the inhalation of volatiles.

Two separate vapor intrusion evaluations were conducted. The first addressed the risks to workers associated with current buildings at the Facility (not including the covered open-air fueling station located in the middle of the Facility). As recommended in EPA guidance (2002c), only those samples collected within 100 feet of existing buildings were used to estimate indoor vapor concentrations. Thus, groundwater samples collected from shallow wells A-20 and GA-34 were used to evaluate risks. Data from samples farther than 100 feet from current buildings were not used to estimate exposure because chemical migration at this distance without a natural or man-made conduit is considered unlikely.

The second evaluation assessed risks to workers based on hypothetical future buildings at the Facility. This scenario included all other groundwater samples to determine hypothetical vapor intrusion risks if additional buildings were to be constructed in the future. Figure 3-2 shows the samples groups used for these two scenarios.

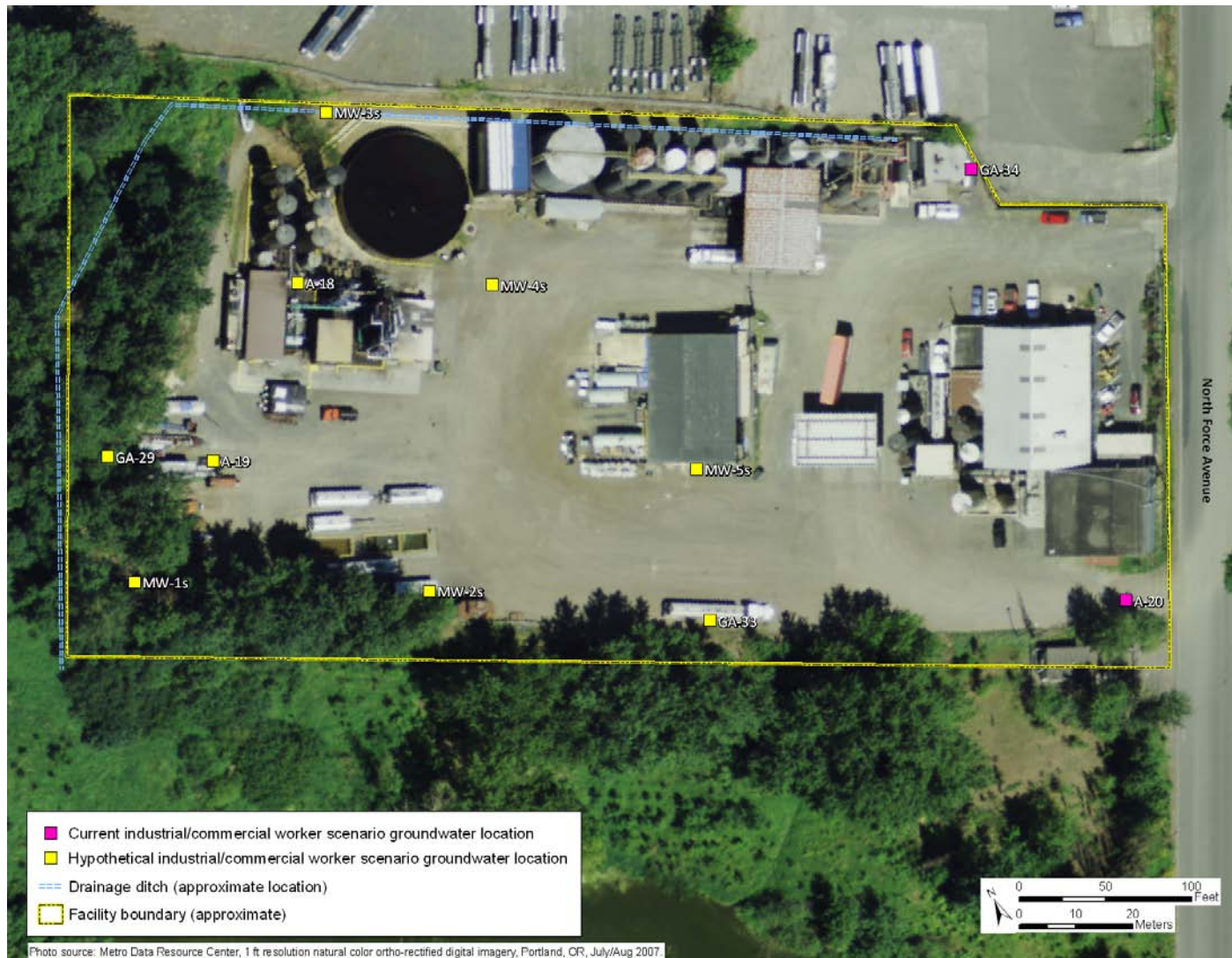


Figure 3-2. Sampling Locations for the Industrial/Commercial Worker Vapor Intrusion Scenarios

Exposure pathways that were considered incomplete or complete and insignificant for the industrial/commercial worker vapor intrusion scenario are listed below, along with rationale regarding the exclusion of these pathways:

- **Dermal soil contact or incidental soil ingestion:** Exposure to soil was considered to be low relative to the inhalation of volatiles.
- **Inhalation of airborne soil particulates:** Exposure via the inhalation of airborne soil particulates was considered to be low.
- **Dermal sediment contact or incidental sediment ingestion:** Workers at the Facility were not expected to come into contact with lake sediment.
- **Dermal water contact or incidental water ingestion:** Exposure to water was not expected based on the daily activities of workers at the Facility.
- **Drinking water ingestion:** Groundwater at the Facility is not a source of drinking water.
- **Fish ingestion:** Workers at the Facility were not expected to consume fish from Force Lake.

3.1.4 Force Lake Recreational User RME Scenario

Exposure to chemicals at the Study Area could occur through recreation-associated activities at Force Lake and in the surrounding wetlands, including bird watching, remote-control boating, or golf ball retrieval. In addition, some individuals may be exposed to lake sediment or water while fishing at Force Lake. The recreational user RME scenario was designed to estimate risks from the following exposure routes:

- **Lake water:** dermal contact and incidental ingestion
- **Lake sediment:** dermal contact and incidental ingestion
- **Wetland soils:** dermal contact and incidental ingestion

Risks from exposure to each of these media were calculated separately, and were then summed to calculate the risk to recreational users across exposure media.

In order to ensure that this scenario is protective, the total exposure duration of 30 years (EPA 1989) was assumed to start at age 0 to combine the most sensitive exposure period with adult exposure. To allow for the use of age-specific exposure parameters, exposure parameters for three separate age groups were used). The first age group was younger children (up to 6 years of age), the second age group was older children (7 to 16 years of age), and the third age group was adults (17 to 30 years of age). Integrated risks are presented across these age groups.

As discussed in the RI/FS Work Plan (Bridgewater et al. 2008b) and risk assessment scoping memorandum (Windward and Bridgewater 2008a), exposure to wetland soil was assessed using all surface wetland and

ditch soil samples; subsurface soil samples were not included because contact with these deeper soils is unlikely during recreational activities. Exposure to lake sediment was assessed using all surface sediment samples collected from Force Lake. As noted above for the wetland soil samples, contact with deeper lake sediment during recreational activities is unlikely. Additionally, the analysis of subsurface sediment samples during Phase 2 of the RI sampling found that chemical concentrations were low in subsurface sediment. Sediment samples collected from North Lake were not included in this HHRA (see Sections 2.3.1).

Exposure to surface water was assessed using all water samples collected from Force Lake; no water samples were collected from North Lake. This evaluation of risks associated with Force Lake surface water also provided an indication of the level of risks associated with stormwater from the Facility (i.e., low risks associated with exposure to Force Lake surface water would indicate that the concentrations in stormwater did not increase concentrations in lake water to levels that would result in risks greater than EPA's target risk range).

Exposure pathways that were considered incomplete or complete and insignificant for the Force Lake recreational user RME scenario are listed below, along with rationale regarding the exclusion of these pathways:

- **Inhalation of airborne soil particulates or inhalation of chemicals volatilized from soil:** Risks associated with inhalation were not assessed because of the low exposure potential and because risks from inhalation were expected to be insignificant compared to risks from dermal and incidental ingestion of soil.
- **Drinking water ingestion:** Groundwater and surface water at the Study Area are not sources of drinking water.
- **Inhalation of chemicals volatilized from water:** Risks associated with inhalation were not assessed because of the low exposure potential and because risks from inhalation were expected to be insignificant compared to risks from dermal and incidental ingestion.

Cumulative risks for the recreational user and Force Lake fish consumer scenarios are presented in Section 5.5.

3.1.5 Force Lake Fish Consumer RME Scenario

The Force Lake fish consumer scenario was evaluated in response to EPA comments on the risk assessment scoping memorandum (EPA 2008c; Windward and Bridgewater 2008b) to assess risks to humans if they were to consume fish from Force Lake. As with the Force Lake recreational user scenario, the total exposure duration of 30 years was assumed to start at age 0 to combine the most sensitive exposure period (0 to 6 years of age) with adult exposure. To allow for the use of age-specific exposure parameters, exposure parameters for three separate age groups were used as described in Section 3.1.4.

Based on the available information regarding the fish population present in Force Lake, the observed fishing frequency, and the availability of public access (see Section 3.3.3), the group most likely to be fishing at Force Lake would be recreational anglers. It is possible that ethnic populations or transient individuals may fish at Force Lake to supplement their diets. However, given the results of the 2009 fish survey, it is unlikely that individuals could rely solely on fish from Force Lake for their diet. Using conservative assumptions to assess risks for the Force Lake fish consumer RME scenario, anglers were assumed to visit the lake several times a year during the warmer months to fish. Based on the available information on the fish population present in the lake and the use of the lake by anglers (see Section 3.3.3), anglers were assumed to eat a total of 6 meals per year of fish collected from Force Lake.

Risks associated with fish consumption are assessed in Section 5.3.5 based on estimated fish tissue concentrations using biota-sediment accumulation factors (BSAFs) and all surface sediment data from Force Lake (see Attachment 2). In addition, because of the possibility that individuals could be exposed through multiple exposure scenarios, cumulative risks from the Force Lake fish consumer RME scenario and the Force Lake recreational user RME scenario are presented in Section 5.5.

Exposure pathways that were considered incomplete or complete and insignificant for the Force Lake recreational user RME scenario are listed below, along with rationale regarding the exclusion of these pathways:

- **Dermal contact with and incidental ingestion of soil:** The potential for exposure to soil during fishing was considered to be low (note that risks based on water exposure were assessed separately as discussed in Section 3.1.4; the cumulative risks are presented in Section 5.5).
- **Inhalation of airborne soil particulates or inhalation of chemicals volatilized from soil:** Risks associated with inhalation were not assessed because of the low exposure potential and because risks from inhalation were expected to be insignificant during fishing.
- **Dermal contact with and incidental ingestion of sediment:** The potential for exposure to sediment during fishing was considered to be low (note that risks based on sediment exposure were assessed separately as discussed in Section 3.1.4, the cumulative risks are presented in Section 5.5).
- **Dermal contact with and incidental ingestion of water:** The potential for exposure to water during fishing was considered to be low (note that risks based on water exposure were assessed separately as discussed in Section 3.1.4, the cumulative risks are presented in Section 5.5).
- **Drinking water ingestion:** Groundwater and surface water at the Study Area is not a source of drinking water.

- **Inhalation of chemicals volatilized from water:** Risks associated with inhalation were not assessed because of the low potential for exposure to volatile chemicals while fishing.

3.1.6 Selection of Exposure Scenarios for Quantification

EPA guidance (1989) states that “actions at Superfund sites should be based on an estimate of the RME expected to occur under both current and future land-use conditions.”

Specific exposure assumptions were developed to quantify exposure pathways for the scenarios shown in Figure 3-1. A complete exposure pathway includes an exposure medium and exposure point; a potentially exposed population, including receptor age (i.e., adult vs. child); and an exposure route. Table 3-1 presents the exposure routes illustrated in the CSM and provides the rationale for the selection or exclusion of those pathways identified as either complete and significant or complete and insignificant. The exposure parameters for these scenarios are discussed in Section 3.3.

3.2 COPC Screening and Evaluation

Based on EPA guidance (1996a), a risk-based screening approach was used to develop a list of COPCs from the list of contaminants of interest (COIs) for detailed analysis in the baseline HHRA. A scenario-specific COPC list was developed based on the most appropriate screening levels for each scenario.

All chemicals analyzed in soil, sediment, or water were considered as COIs. Figure 3-3 presents the screening process used to identify the COPCs from the COI list. Screening was conducted separately for each media type relevant to each scenario using the regional screening levels (RSLs) discussed in Section 3.2.1.⁶ The full results of the COPC screen are presented in Attachment 3.

⁶ RSLs are concentrations associated with specific risk levels, behaviors, and exposure pathways that are used for screening purposes. More detail is provided in Section 3.2.1.

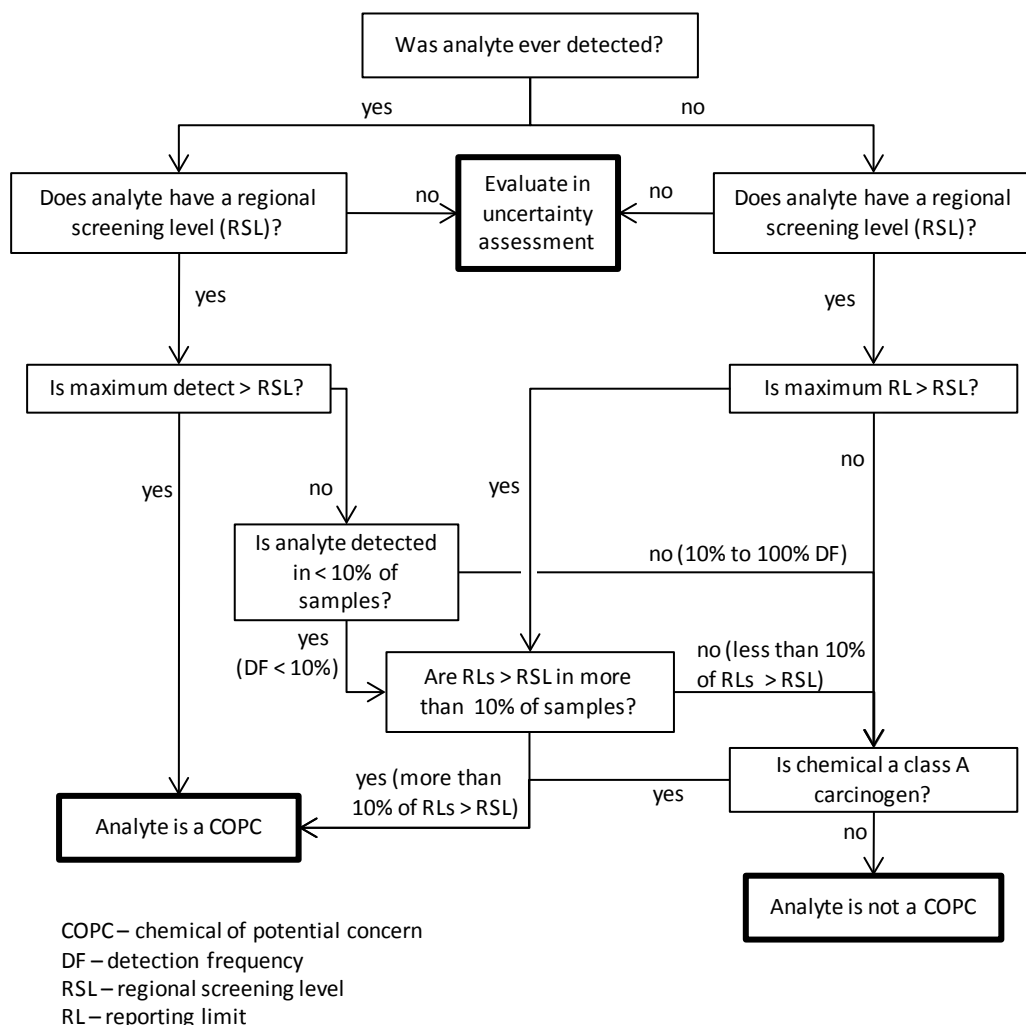


Figure 3-3. Human health COPC screening process

3.2.1 RSLs for COPC Screen or Screening-Level Assessment

RSLs were compiled on a media- and scenario-specific basis for the identification of COPCs as described above. For all media, criteria for non-carcinogenic endpoints were adjusted per EPA Region 10 risk assessment guidance (1996a) to be based on a hazard quotient (HQ) of 0.1 to account for cumulative risks from non-carcinogenic COIs.⁷ RSLs for carcinogenic COIs were based on an excess cancer risk of 1×10^{-6} and were not modified as was necessary for the RSLs based on non-carcinogenic endpoints.

In addition, as discussed in Section 2.2.5, it should be noted that TPH were assessed as aliphatic fractions and as various PAH and VOC components in the COPC screen. Aliphatic TPH, assumed to be 85%

⁷ EPA RSLs and DEQ thresholds for human health are based on a hazard quotient of 1 for all media.

of each TPH fraction based on ATSDR (1999), was compared with DEQ screening levels.

3.2.1.1 Exposure to Groundwater and Lake Surface Water

To determine COPCs based on exposure to groundwater and surface water, the following screening criteria are available, as shown in Attachment 3:

- EPA ambient water quality criteria (AWQC) for human water/organism consumption and organism consumption (2009c)
- EPA RSLs for tap water (2009i)
- DEQ human health occupational risk-based concentrations (RBCs) for the following pathways: ingestion and inhalation from tap water, volatilization to outdoor air, and exposure to groundwater during excavation (2007b)
- EPA non-zero maximum contaminant level goals and maximum contaminant levels (2009b)
- DEQ groundwater RBCs for TPH fractions (2003)

The lowest value for each COI was selected from these four sources for use in COPC selection for the Force Lake recreational user RME scenario and the screening assessment for hypothetical future residents. For the industrial (construction/trenching) worker and future outdoor worker scenarios, the lowest value from the DEQ source was used because worker-specific values were available only from this source.

For the industrial/commercial worker vapor intrusion scenario, groundwater concentrations were compared with screening levels from EPA's OSWER Draft *Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (EPA 2002c).

3.2.1.2 Exposure to Soil (Industrial)

To identify COPCs based on exposure to Facility soils through industrial activities, surface and intermediate subsurface soil concentrations were compared to industrial soil screening levels for the two industrial worker scenarios, as stated in the RI/FS Work Plan (Bridgewater et al. 2008b). Samples were screened against the lowest value from the following criteria, as shown in Attachment 3:

- EPA RSLs for industrial exposure to soil (2009i)
- DEQ human health occupational, construction worker, or excavation worker RBCs for the following exposure routes: soil ingestion, dermal absorption, and inhalation; volatilization to outdoor air; and leaching to groundwater (2007b)
- DEQ soil RBCs for TPH fractions (2003)

3.2.1.3 Exposure to Soil (Residential or Recreational)

To determine COPCs based on residential or recreational exposure to soils, concentrations were compared to residential soil screening levels, as stated in the RI/FS Work Plan (Bridgewater et al. 2008b). It should be noted that for the Force Lake recreational user RME scenario, no recreation-specific screening criteria are available. As a health-protective approach, residential criteria were selected, even though the wetlands are designated as open space and are not zoned for industrial or residential use. Use of the residential criteria as a default results in highly conservative screening values because the exposure frequency for residential use is much higher than that for recreational use.

Samples were screened against the lowest value from the following criteria, as shown in Attachment 3:

- EPA RSLs for residential exposure to soil (2009i)
- DEQ RBCs for soil ingestion, dermal contact, and inhalation; residential exposure through volatilization to outdoor air; and residential exposure through leaching to groundwater (2007b)
- DEQ soil RBCs for TPH fractions (2003)

3.2.1.4 Exposure to Lake Sediment (Residential or Recreational)

To determine COPCs based on exposure to lake sediment, sediment data were screened against the same residential criteria used to screen soils. No sediment-specific criteria are available for assessing risks to human health. Like the wetlands, the lake is designated as open space and is part of the Pen 1 natural resource management planning area, and thus the use of these soil-based residential screening criteria as a default is highly conservative. As with wetland soil, the lowest value from the available criteria was used.

3.2.1.5 Fish Tissue Consumption

To determine COPCs based on fish tissue consumption, calculated fish tissue concentrations were screened against EPA Region 3 fish tissue screening levels (2009h), which are shown in Table 9 of Attachment 3. Methods for calculating chemical concentrations in fish tissue are described in Attachment 2.

3.2.2 Scenario-Specific COPCs

Using the process outlined in Figure 3-3 and the RSLs described in Section 3.2.1, scenario- and media-specific COPC lists were developed. Additional details regarding this selection process are provided in Attachment 3.

As noted in Figure 3-3, all known human carcinogens were retained as COPCs, even when concentrations were less than the applicable RSLs, as directed by EPA (2009a, 2010a). Known human carcinogens include arsenic, benzene, and vinyl chloride (EPA 2006c; accessed January

2010).⁸ Tables 3-2 through 3-6 present the COPCs based on both detected and non-detected concentrations in the applicable media for each scenario. Those COPCs that screen in based only on their status as known human carcinogens are noted in the tables.

Table 3-2. COPCs for the Industrial (Construction/Trenching) Worker RME Scenario

Detected COPCs	Non-Detected COPCs
Facility Soil	
Metals Arsenic Cobalt Copper Lead PAHs Naphthalene cPAH TEQ PCBs Total PCBs Pesticides Total DDTs VOCs 1,1-Dichloroethane 1,2,4-Trimethylbenzene 1,3,5-Trimethylbenzene Benzene Chlorobenzene cis-1,2-Dichloroethene Dichloromethane Ethylbenzene trans-1,2-Dichloroethene Trichloroethene Vinyl chloride Total xylene TPH TPH-gasoline (aliphatic)	Other SVOCs 2,6-Dinitrotoluene 3,3'-Dichlorobenzidine N-Nitroso-di-n-propylamine Pesticides Dieldrin alpha-BHC Toxaphene VOCs 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane (EDB) 1,2-Dichloroethane Bromodichloromethane Bromomethane Carbon tetrachloride Chloroform
Groundwater	
Metals Arsenic (total) ^a Lead (total) Manganese (total) ^a PAHs Naphthalene Other SVOCs 1,4-Dichlorobenzene Pesticides	PAHs cPAH TEQ Other SVOCs 2,6-Dinitrotoluene 3,3'-Dichlorobenzidine Hexachlorobenzene Pentachlorophenol PCBs Total PCBs

⁸ It should be noted that some forms of nickel (i.e., nickel refinery dust and nickel subsulfide) are considered Class A carcinogens, but these forms of nickel are related to nickel refineries and are not expected to be present at the Study Area. Nickel (soluble salts) was considered the most appropriate form of nickel for this HHRA.

Table 3-2. COPCs for the Industrial (Construction/Trenching) Worker RME Scenario

Detected COPCs	Non-Detected COPCs
Total DDTs VOCs 1,2,4-Trimethylbenzene 1,3,5-Trimethylbenzene Benzene Chlorobenzene n-Propylbenzene tert-Butyl methyl ether Vinyl chloride	Pesticides Aldrin ^b Dieldrin ^b alpha-BHC Heptachlor Heptachlor epoxide Toxaphene (filtered and unfiltered) VOCs 1,2-Dibromoethane (EDB) 1,2-Dichloroethane Bromodichloromethane Bromomethane Carbon tetrachloride Chloroform Trichloroethene

^a Both the total and dissolved fraction were greater than the screening level. To be conservative, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

^b Concentrations in both the filtered and unfiltered groundwater samples were greater than the RSL.

BHC – benzene hexachloride

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

EDB – ethylene dibromide

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

Table 3-3. COPCs for the Future Outdoor Worker RME Scenario

Detected COPCs	Non-Detected COPCs
Facility Soil	
Metals Arsenic Cobalt Copper Lead PAHs Naphthalene cPAH TEQ PCBs Total PCBs Pesticides Total DDTs VOCs 1,1-Dichloroethane 1,2,4-Trimethylbenzene 1,3,5-Trimethylbenzene Benzene cis-1,2-Dichloroethene Dichloromethane Ethylbenzene trans-1,2-Dichloroethene Trichloroethene Vinyl chloride Total xylenes TPH TPH-gasoline (aliphatic)	Other SVOCs 2,6-Dinitrotoluene 3,3'-Dichlorobenzidine N-Nitroso-di-n-propylamine Pesticides Aldrin Dieldrin alpha-BHC gamma-BHC Heptachlor epoxide Toxaphene VOCs 1,2-Dibromoethane (EDB)

BHC – benzene hexachloride
 COPC – contaminant of potential concern
 cPAH – carcinogenic polycyclic aromatic hydrocarbon
 DDT – dichlorodiphenyltrichloroethane
 EDB – ethylene dibromide
 PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl
 RME – reasonable maximum exposure
 RSL – regional screening level
 SVOC – semivolatile organic compound
 TEQ – toxic equivalent
 TPH – total petroleum hydrocarbons
 VOC – volatile organic compound

Table 3-4. COPCs for the Industrial/Commercial Worker Vapor Intrusion Scenario

Detected COPCs ^a	Non-Detected COPCs ^a
VOCs Benzene ^b Vinyl chloride ^b	Other SVOCs Hexachlorobutadiene VOCs 1,1-Dichloropropene 1,2-Dibromoethane (EDB) Bromoform cis-1,3-Dichloropropene trans-1,3-Dichloropropene

^a Per EPA (2002c) guidance, chemicals that have either molecular weights greater than 200 g/mole or have a Henry's Law constant less than 1×10^{-5} are not volatile by definition and thus are not evaluated for vapor intrusion risks.

^b Maximum concentration is less than the RSL, but chemical is a COPC because it is a known human carcinogen.

COPC – contaminant of potential concern

EDB – ethylene dibromide

EPA – US Environmental Protection Agency

SVOC – semivolatile organic compound

VOC – volatile organic compound

Table 3-5. COPCs for the Force Lake Recreational User RME Scenario

Detected COPCs	Non-Detected COPCs	
Wetland Soil		
Metals Aluminum Antimony Arsenic Chromium Cobalt Copper Iron Lead Manganese Vanadium PAHs Naphthalene c PAH TEQ PCBs Total PCBs Pesticides Total DDTs VOCs Benzene Trichloroethene TPH TPH-gasoline (aliphatic) TPH-diesel (aliphatic)	Metals Thallium Other SVOCs 2,4-Dinitrophenol 2,4-Dinitrotoluene 2,6-Dinitrotoluene 3,3'-Dichlorobenzidine 4,6-Dinitro-o-cresol Atrazine bis(2-chloroethyl)ether N-Nitroso-di-n-propylamine Pentachlorophenol	Pesticides Aldrin Dieldrin alpha-BHC gamma-BHC Toxaphene VOCs 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane (EDB) 1,2-Dichloroethane Bromodichloro methane Chloroform Vinyl chloride
Force Lake Sediment		
Metals Arsenic Chromium Cobalt Lead Vanadium PAHs cPAH TEQ TPH TPH-gasoline (aliphatic)	Pesticides alpha-BHC Dieldrin Toxaphene	VOCs 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane (EDB) 1,2-Dichloroethane Benzene ^a Bromodichloro methane Chloroform Trichloroethene Vinyl chloride

Table 3-5. COPCs for the Force Lake Recreational User RME Scenario

Detected COPCs	Non-Detected COPCs	
Force Lake Surface Water		
Metals Arsenic (total) ^b	Metals Cobalt (dissolved and total) PAHs cPAH TEQ Other SVOCs 1,2,4-Trichlorobenzene 1,4-Dichlorobenzene Hexachlorobenzene PCBs Total PCBs Pesticides Aldrin Dieldrin alpha-BHC beta-BHC gamma-Chlordane Total chlordane Heptachlor Heptachlor epoxide Toxaphene	VOCs 1,1,1,2-Tetrachloroethane 1,1,2,2-Tetrachloroethane 1,1,2-Trichloroethane 1,2,3-Trichloropropane 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane (EDB) 1,2-Dichloroethane 1,2-Dichloropropane Benzene Bromodichloromethane Bromomethane Carbon tetrachloride Chloroform cis-1,3-Dichloropropene Dibromochloromethane Tetrachloroethene trans-1,3-Dichloropropene Trichloroethene Vinyl chloride

^a Maximum concentration is less than the RSL, but chemical is a COPC because it is a known human carcinogen.

^b Both the total and dissolved fraction were greater than the screening level. To be conservative, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

BHC – benzene hexachloride

COPC – contaminant of potential concern

cPAH – carcinogenic PAH

EDB – ethylene dibromide

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

Table 3-6. COPCs for the Force Lake Fish Consumer RME Scenario

Detected COPCs	Non-Detected COPCs
Metals Arsenic Barium Cadmium Cobalt Copper Lead Mercury Nickel Vanadium Zinc PCBs Total PCBs Pesticides Total DDTs	Metals Antimony Selenium Pesticides Aldrin Dieldrin alpha-BHC beta-BHC gamma-BHC alpha-Chlordane Total chlordane Heptachlor Heptachlor epoxide Toxaphene VOCs 1,2,3-Trichloropropane 1,2-Dibromo-3-chloropropane Benzene ^a Vinyl chloride

Note: COPCs for the Force Lake fish consumer scenario were determined based on calculated fish tissue concentrations using Force Lake sediment data and literature BSAFs (see Attachment 2).

^a Maximum concentration is less than the RSL, but chemical is a COPC because it is a known human carcinogen.

BHC – benzene hexachloride

BSAF – biota-sediment accumulation factor

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

PCB – polychlorinated biphenyl

RSL – regional screening level

RME – reasonable maximum exposure

VOC – volatile organic compound

Based on this COPC screen, the risks for detected COPCs are presented in Section 5.0. The non-detected COPCs are discussed in the uncertainty analysis (Section 6.3.1). In addition, it should be noted that for scenarios that consider exposure to multiple exposure media (e.g., facility soil and groundwater for the future outdoor worker), the COPC lists for these scenarios were not necessarily the same. For example, in Table 3-2, copper is a COPC for the industrial (construction/trenching) worker scenario based on exposure to Facility soil, but it is not a COPC for groundwater. Thus, when risks from Facility soil and groundwater were summed for this scenario, only the risk from copper based on Facility soil was included because the copper risk from groundwater was assumed to be insignificant since it was not identified as a COPC for this pathway. Table 3-7 summarizes the numbers of COPCs that were identified for each scenario.

Table 3-7. Summary of COPCs by Scenario

Scenario	Table	Detected COPCs	Non-Detected COPCs
Industrial (Construction/Trenching) Worker RME Scenario			
Facility soil	Table 3-2	21	13
Groundwater		14	19
Future Outdoor Worker RME Scenario			
Facility soil	Table 3-3	20	10
Industrial/Commercial Worker Vapor Intrusion Scenario			
Groundwater	Table 3-4	2 ^a	7
Force Lake Recreational User RME Scenario			
Wetland soil	Table 3-5	16	21
Lake sediment		6	11
Lake surface water		1	34
Force Lake Fish Consumer RME Scenario			
Fish tissue	Table 3-6	12	15

^a Benzene and vinyl chloride, the only detected COPCs, were identified as COPCs based only on their classification as a known human carcinogens not because concentrations were greater than screening levels.

COPC – contaminant of potential concern

RME – reasonable maximum exposure

3.3 Selection of Exposure Parameters and Calculation of Chronic Daily Intake

This section presents the equations used to calculate the CDI rates (Section 3.3.1), the scenario-specific parameters needed to calculate the CDIs (Section 3.3.2), the method used to calculate COPC in fish tissue (Section 3.3.3), the exposure point concentrations (Section 3.3.4), and the methods used to calculate exposure to lead (Section 3.3.5).

3.3.1 Chronic Daily Intake Rate Calculations

COPC exposure is expressed as the CDI rate. The CDI is calculated based on an EPC and site-specific exposure parameters.

This section presents the equations that were used to calculate the CDI for the following exposure routes:

- Incidental ingestion of soil or sediment (Equation 3-1)
- Incidental ingestion of water (e.g., during swimming or wading) (Equation 3-2)
- Dermal absorption from soil or sediment (Equation 3-3)
- Dermal absorption from water (Equation 3-4), including calculations of the absorbed dose per event (Equations 3-5 to 3-7)

- Inhalation of COPCs associated with airborne soil particulates (Equation 3-8), including the calculation of respirable soil particulates in the air (Equation 3-9)
- Inhalation of COPCs associated with vapors

Incidental ingestion of soil or sediment:

$$CDI_{\text{oral}} = \frac{(EPC \times IR \times FI \times EF \times ED \times CF1)}{(BW \times AT)} \quad \text{Equation 3-1}$$

Where:

CDI	mg/kg-day	COPC-specific chronic daily intake rate
EPC	mg/kg	COPC-specific exposure point concentration
IR	g/day	ingestion rate
FI	unitless	fractional intake from site media
EF	days/yr	exposure frequency
ED	years	exposure duration
CF1	kg/g	conversion factor
BW	kg	body weight
AT	days	averaging time (cancer or non-cancer)

Incidental ingestion of water:

$$CDI_{\text{oral}} = \frac{(EPC \times CR \times FI \times ET \times EF \times ED)}{(BW \times AT)} \quad \text{Equation 3-2}$$

Where:

CDI	mg/kg-day	COPC-specific chronic daily intake rate
EPC	mg/L	COPC-specific exposure point concentration
CR	L/hour	contact rate
FI	unitless	fractional intake from site media
ET	hours/day	event time
EF	days/yr	exposure frequency
ED	years	exposure duration
BW	kg	body weight
AT	days	averaging time (cancer or non-cancer)

Dermal absorption from soil or sediment:

$$CDI_{\text{dermal-soil}} = \frac{(EPC \times ABS \times SA \times AF \times FI \times EF \times ED \times CF2)}{(BW \times AT)} \quad \text{Equation 3-3}$$

Where:

CDI	mg/kg-day	COPC-specific chronic daily intake rate
EPC	mg/kg	COPC-specific exposure point concentration
ABS	unitless	dermal absorption fraction (EPA 2004)
SA	cm ²	exposed skin surface area
AF	mg/cm ²	sediment or soil to skin adherence factor by event (EPA 1997)
FI	unitless	fractional intake from site media
EF	days/yr	exposure frequency
ED	years	exposure duration
CF2	kg/mg	conversion factor

BW kg body weight
AT days averaging time (cancer or non-cancer)

Dermal absorption from water:

$$CDI_{\text{dermal-water}} = \frac{(DA_{\text{event}} \times SA \times FI \times EV \times EF \times ED)}{(BW \times AT)} \quad \text{Equation 3-4}$$

Where:

CDI	mg/kg-day	COPC-specific chronic daily intake rate
DA _{event}	mg/cm ² -event	COPC-specific absorbed dose per event
SA	cm ²	exposed skin surface area
FI	unitless	fractional intake from site media
EV	events/day	event frequency
EF	days/yr	exposure frequency
ED	years	exposure duration
BW	kg	body weight
AT	days	averaging time (cancer or non-cancer)

Calculation of the absorbed dose per event (EPA 2004):

For organic COPCs when $ET \leq t^*$:

$$DA_{\text{event}} = 2 \times FI \times K_p \times EPC \times \sqrt{\frac{6 \times T \times ET}{\pi}} \quad \text{Equation 3-5}$$

For organic COPCs when $ET > t^*$:

$$DA_{\text{event}} = FI \times K_p \times EPC \times \left[\frac{ET}{1+B} + 2 \times T \times \left(\frac{1+3B+3B^2}{(1+B)^2} \right) \right] \quad \text{Equation 3-6}$$

For inorganic COPCs:

$$DA_{\text{event}} = K_p \times EPC \times ET \quad \text{Equation 3-7}$$

Where:

DA _{event}	mg/cm ² -event	COPC-specific absorbed dose per event
FI	unitless	fractional intake from site media
K _p	cm/hr	COPC-specific dermal permeability coefficient of compound in water
EPC	mg/cm ³	COPC-specific exposure point concentration
T	hrs/event	COPC-specific lag time per event
ET	hrs	event time
t [*]	hrs	COPC-specific time to reach steady state
B	unitless	COPC-specific dimensionless ratio of the permeability coefficient across the viable epidermis (ve)

The COPC-specific values for these parameters along with the CDI calculations are presented in Attachment 5.

Inhalation of airborne soil particulates and inhalation of COPCs volatilized from soil or water:

As discussed in EPA's supplemental guidance for inhalation risk assessment (EPA 2009j), risks associated with the inhalation of COPCs should be assessed using Equation 3-8, not the generic equation presented in Part A of Risk Assessment Guidance for Superfund (RAGS). Per EPA (2009j), the calculated exposure concentration is time-weighted over the duration of exposure for the scenario and incorporates information regarding activity patterns at the site.

$$EC = \frac{(CA \times FI \times ET \times EF \times ED)}{(AT \times CF3)} \quad \text{Equation 3-8}$$

Where:

EC	µg/m ³	time-weighted COPC-specific exposure concentration
CA _{particulates}	µg/m ³	COPC-specific concentration of respirable particulates in the air
FI	unitless	fractional intake from site media
ET	hrs/day	event time
EF	days/yr	exposure frequency
ED	years	exposure duration
AT	days	averaging time (cancer or non-cancer)
CF3	hrs/day	conversion factor

Calculation of COPC concentrations associated with soil particulates:

The COPC-specific concentration of respirable soil particulates in the air is calculated from the COPC concentration in soil based on DEQ guidance (1998) as follows:

$$CA_{\text{particle}} = \frac{C_{\text{soil}}}{PEF} \times F_s \times CF4 \quad \text{Equation 3-9}$$

Where:

CA _{particulates}	µg/m ³	COPC-specific concentration of respirable particulates in the air
C _{soil}	mg/kg dw	COPC concentration in soil
PEF	m ³ /kg	particulate emission factor
F _s	unitless	fraction of soil contaminated
CF4	µg/mg	conversion factor

A default particulate emission factor (PEF) of $1.32 \times 10^9 \text{ m}^3/\text{kg}$ was used, as recommended by EPA (1996b). This PEF was derived using default values for a rapid assessment procedure applicable to a typical hazardous waste site, where the surface contamination provides the potential for a relatively constant emission over an extended period of time (e.g., years). This PEF represents an annual average emission rate based on wind erosion and should be used with chronic health criteria.

Calculation of COPC concentrations associated with airborne vapors:

COPC concentrations in outdoor air were modeled from soil and groundwater concentrations using a series of equations based on equilibrium partitioning. The use of an equilibrium partitioning model to calculate vapor concentrations represents a significant source of uncertainty. Because of the relatively large number of equations and variables that were used to calculate these concentrations, a detailed discussion of the methods is presented in Attachment 4.

3.3.2 Exposure Parameters

The exposure parameters needed to calculate the CDI rates are presented in this section. The tables that present the parameters for each scenario are listed below:

- **Industrial (construction/trenching) worker RME scenario:** Tables 3-8 to 3-11
- **Future outdoor worker RME scenario:** Tables 3-12 to 3-14
- **Industrial/commercial worker vapor intrusion scenario:** No scenario-specific parameters were needed for this scenario because risks for these COPCs were calculated using the default exposure parameters that were used by EPA (2002c) to calculate the vapor intrusion screening levels, as discussed in Section 5.3.3.
- **Force Lake recreational user RME scenario:** Tables 3-15 to 3-18
- **Force Lake fish consumer RME scenario:** Table 3-19

Scenario-specific parameters were not developed for the screening assessment for hypothetical future residents because default exposure parameters were used to evaluate risks associated with this scenario (Attachment 1).

Table 3-8. Daily Intake Calculations – Incidental Ingestion of Soil During Industrial (Construction/Trenching) Work

Scenario timeframe: Current/future Exposure media: Facility soil Exposure route: Ingestion (incidental) Intake equation: $CDI \text{ (mg/kg dw)} = EPC \times IRs \times FI \times EF \times ED \times CF \times 1/BW \times 1/AT$			
Parameter Code	Parameter Description	Value	Rationale and Reference
EPC	exposure point concentration (mg/kg dw)	na	COPC specific
IR-s	incidental soil ingestion rate (g/day)	0.33	based on a construction worker (EPA 2002d)
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	250	based on a construction worker (DEQ 2003)
ED	exposure duration (yrs)	1	
CF	conversion factor	0.001	conversion from kg to g
BW	body weight (kg)	70	default value (EPA 1989)
AT_c	cancer averaging time (days)	25,550	default value (EPA 1989)
AT_nc	non-cancer averaging time (days)	365	EPA (1989)

CDI – chronic daily intake

DEQ – Oregon Department of Environmental Quality

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-9. Daily Intake Calculations – Dermal Contact with Soil During Industrial (Construction/Trenching) Work

Scenario timeframe: Current/future Exposure media: Facility soil Exposure route: Ingestion (incidental) Intake equation: $CDI \text{ (mg/kg dw)} = EPC \times ABS \times AF \times SA \times FI \times EF \times ED \times CF \times 1/BW \times 1/AT$			
Parameter Code	Parameter Description	Value	Rationale and Reference
EPC	exposure point concentration (mg/kg dw)	na	COPC specific
ABS	dermal absorption fraction	na	COPC specific
AF	adherence factor by event (mg/cm ²)	1	EPA (2004)
SA	exposed skin surface area (cm ²)	3,300	based on an excavation/construction worker (DEQ 2003; EPA 2002d)
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	250	based on a construction worker (DEQ 2003)
ED	exposure duration (yrs)	1	
CF	conversion factor	0.000001	conversion from mg to kg
BW	body weight (kg)	70	default value (EPA 1989)
AT_c	cancer averaging time (days)	25,550	default value (EPA 1989)
AT_nc	non-cancer averaging time (days)	365	EPA (1989); equal to ED × 365 days

CDI – chronic daily intake

DEQ – Oregon Department of Environmental Quality

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-10. Daily Intake Calculations – Dermal Contact with Groundwater During Industrial (Construction/Trenching) Work

Scenario time frame: Current/future Exposure media: Groundwater Exposure route: Dermal Intake equation: $CDI \text{ (mg/kg dw)} = DA_{\text{event}} \times SA \times EF \times EV \times ED \times 1/BW \times 1/AT$			
Parameter Code	Parameter Description	Value	Rationale and Reference
DA _{event}	absorbed dose per event	na	COPC specific (see Equations 3-5 to 3-7)
SA	exposed skin surface area (cm ²)	3,300	based on an excavation/construction worker (DEQ 2003; EPA 2002d)
EF	exposure frequency (d/yr)	250	based on a construction worker (DEQ 2003)
EV	event frequency (events/day)	1	
ED	exposure duration (yrs)	1	
BW	body weight (kg)	70	default value (EPA 1989)
AT _c	cancer averaging time (days)	25,550	EPA (1989)
AT _{nc}	non-cancer averaging time (days)	365	EPA (1989); equal to ED × 365 days
FI ^a	fractional intake from site	1	assumes 100% exposure to site
ET ^a	exposure time (hrs/day)	2	based on a construction worker (DEQ 2003)

^a These parameters are not listed in the CDI equation shown in this table, but are scenario-specific parameters needed to calculate the absorbed dose per event (DA_{event}).

CDI – chronic daily intake

DEQ – Oregon Department of Environmental Quality

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-11. Daily Intake Calculations – Inhalation of COPCs from Soil/Water During Industrial (Construction/Trenching) Work

Scenario timeframe: Current/future			
Exposure media: Facility soil and groundwater			
Exposure route: Inhalation of volatiles (from soil and groundwater) and particulates (from soil)			
Volatilization intake equation: $EC_{\text{vapor}} (\mu\text{g}/\text{m}^3) = (CA_{\text{vapor}} \times ET \times EF \times ED)/AT$			
Particulate intake equation: $EC_{\text{particulate}} (\mu\text{g}/\text{m}^3) = CA_{\text{particulates}} \times FI \times ET \times EF \times ED \times (1/AT) \times (1/CF)$			
Parameter Code	Parameter Description	Value	Rationale and Reference
General			
EF	exposure frequency (d/yr)	250	based on a construction worker (DEQ 2003)
ED	exposure duration (yrs)	1	
ET	exposure time (hrs/day)	2	based on a construction worker (DEQ 2003)
BW	body weight (kg)	70	default value (EPA 1989)
FI	fractional intake from site	1	assumes 100% exposure to site
AT _c	cancer averaging time (days)	25,550	default value (EPA 1989)
AT _{nc}	non-cancer averaging time (days)	365	EPA (1989)
CF	conversion factor	24	conversion from days to hours
Volatile Inhalation (from soil and groundwater)			
CA _{vapor}	vapor exposure concentration in the air ($\mu\text{g}/\text{m}^3$)	na	COPC-specific exposure concentration (see Attachment 4 for calculation details)
Particulate Inhalation (from soil)			
CA _{particulates}	particulate exposure concentration in the air ($\mu\text{g}/\text{m}^3$)	na	COPC-specific exposure concentration calculated using Equation 3-9
C _{soil}	concentration in soil (mg/kg dw)	na	COPC-specific soil concentration
PEF ^a	particulate emission factor (m^3/kg)	1.32×10^9	default value (EPA 1996b)
F _s ^a	fraction of soil contaminated	1	default value

^a These parameters are not listed in the CDI equation shown in this table but are scenario-specific parameters needed to calculate the COPC concentration of respirable particulates in the air (Equation 3-9).

CDI – chronic daily intake

COPC – contaminant of potential concern

DEQ – Oregon Department of Environmental Quality

dw – dry weight

EC – exposure concentration

EPA – US Environmental Protection Agency

na – not applicable

Table 3-12. Daily Intake Calculations – Incidental Ingestion of Soil During Future Outdoor Work

Scenario timeframe: Current/future Exposure media: Facility soil Exposure route: Ingestion (incidental) Intake equation: $CDI \text{ (mg/kg dw)} = EPC \times IR\text{-s} \times FI \times EF \times ED \times CF \times 1/BW \times 1/AT$			
Parameter Code	Parameter Description	Value	Rationale and Reference
EPC	exposure point concentration (mg/kg dw)	na	COPC specific
IR-s	incidental soil ingestion rate (g/day)	0.1	based on an occupational worker (DEQ 2003) or outdoor worker (EPA 2002d)
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	250	based on an occupational worker (DEQ 2003) or outdoor worker (EPA 2002d)
ED	exposure duration (yrs)	25	
CF	conversion factor	0.001	conversion from kg to g
BW	body weight (kg)	70	default value (EPA 1989)
AT_c	cancer averaging time (days)	25,550	default value (EPA 1989)
AT_nc	non-cancer averaging time (days)	9,125	EPA (1989)

CDI – chronic daily intake

DEQ – Oregon Department of Environmental Quality

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-13 Daily Intake Calculations – Dermal Contact with Soil During Future Outdoor Work

Scenario timeframe: Current/future Exposure media: Facility soil Exposure route: Ingestion (incidental) Intake equation: $CDI \text{ (mg/kg dw)} = EPC \times ABS \times AF \times SA \times FI \times EF \times ED \times CF \times 1/BW \times 1/AT$			
Parameter Code	Parameter Description	Value	Rationale and Reference
EPC	exposure point concentration (mg/kg dw)	na	COPC specific
ABS	dermal absorption fraction	na	COPC specific
AF	adherence factor by event (mg/cm ²)	0.1	based on an occupational worker (DEQ 2003) or outdoor worker (EPA 2002d)
SA	exposed skin surface area (cm ²)	3,300	
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	250	based on an occupational worker (DEQ 2003) or outdoor worker (EPA 2002d)
ED	exposure duration (yrs)	25	
CF	conversion factor	0.000001	conversion from mg to kg
BW	body weight (kg)	70	default value (EPA 1989)
AT_c	cancer averaging time (days)	25,550	default value (EPA 1989)
AT_nc	non-cancer averaging time (days)	9,125	EPA (1989)

CDI – chronic daily intake

DEQ – Oregon Department of Environmental Quality

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-14. Daily Intake Calculations – Inhalation of COPCs from Soil During Future Outdoor Work

Scenario timeframe: Current/future			
Exposure media: Facility soil			
Exposure route: Inhalation of volatiles (from soil) and particulates (from soil)			
Volatilization intake equation: $EC_{\text{vapor}} (\mu\text{g}/\text{m}^3) = (CA_{\text{vapor}} \times ET \times EF \times ED)/AT$			
Particulate intake equation: $EC_{\text{particulate}} (\mu\text{g}/\text{m}^3) = CA_{\text{particulate}} \times FI \times ET \times EF \times ED \times (1/AT) \times (1/CF)$			
Parameter Code	Parameter Description	Value	Rationale and Reference
General			
EF	exposure frequency (d/yr)	250	based on an occupational worker (DEQ 2003) or outdoor worker (EPA 2002d)
ED	exposure duration (yrs)	25	
ET	exposure time (hrs/day)	8	assumes an 8 hour work day
BW	body weight (kg)	70	default value (EPA 1989)
FI	fractional intake from site	1	assumes 100% exposure to site
AT _c	cancer averaging time (days)	25,550	default value (EPA 1989)
AT _{nc}	non-cancer averaging time (days)	365	EPA (1989)
CF	conversion factor	24	conversion from days to hours
Volatile Inhalation			
CA _{vapor}	vapor exposure concentration in the air ($\mu\text{g}/\text{m}^3$)	na	COPC-specific exposure concentration (see Attachment 4 for calculation details)
Particulate Inhalation			
CA _{particulate}	particulate exposure concentration in the air ($\mu\text{g}/\text{m}^3$)	na	COPC-specific exposure concentration calculated using Equation 3-9
C _{soil}	concentration in soil (mg/kg dw)	na	COPC-specific soil concentration
PEF ^a	particulate emission factor (m^3/kg)	1.32×10^9	default value (EPA 1996b)
F _s ^a	fraction of soil contaminated	1	default value

^a These parameters are not listed in the CDI equation shown in this table but are scenario-specific parameters needed to calculate the COPC concentration of respirable particulates in the air (Equation 3-9).

CDI – chronic daily intake

COPC – contaminant of potential concern

DEQ – Oregon Department of Environmental Quality

dw – dry weight

EC – exposure concentration

EPA – US Environmental Protection Agency

na – not applicable

Table 3-15. Daily Intake Calculations – Incidental Ingestion of Soil or Sediment During Force Lake Recreation

Scenario timeframe: Current/future			
Exposure media: Lake sediment or wetland soil			
Exposure route: Ingestion (incidental)			
Intake equation: CDI (mg/kg dw) = EPC × IRs × FI × EF × ED × CF × 1/BW × 1/AT			
Parameter Code	Parameter Description	Value	Rationale and Reference
General			
EPC	exposure point concentration	na	COPC specific
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	22	based on the assumption that individuals visit the Study Area once per week during the summer (13 weeks) and once per month during the rest of the year (9 months) (Note that EPA (2008b) guidance recommends using site-specific values, which are not available for the Study Area.)
ED	total exposure duration (yrs)	30	EPA (1989)
CF	conversion factor	0.001	conversion from kg to g
AT_c	cancer averaging time (days)	25,550	EPA (1989)
AT_nc	non-cancer averaging time (days)	ED × 365	EPA (1989); equal to ED × 365 days
Adult (aged 17 to 30)			
IR-s_a	incidental ingestion rate (g/day)	0.1	based on an occupational worker (DEQ 2003) or outdoor worker (EPA 2002d)
ED_a	exposure duration (yrs)	14	EPA (1989); 30 yrs minus child exposure durations
BW_a	body weight (kg)	70	default value (EPA 1989)
Older Child (aged 7 to 16)			
IR-s_co	incidental ingestion rate (g/day)	0.2	EPA (1997)
ED_co	exposure duration (yrs)	10	EPA (1991)
BW_co	body weight (kg)	44.3	(EPA 2008b, Table ES-1)
Young Child (aged 0 to 6)			
IR-s_c	incidental ingestion rate (g/day)	0.2	EPA (1997)
ED_c	exposure duration (yrs)	6 ^a	EPA (1991)
BW_c	body weight (kg)	variable by age ^b	EPA (2008b)

^a The total exposure duration is 6 years, but exposure is calculated in 1-year increments by age class (< 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6 years). For incidental ingestion, Equation 3-1 was modified as follows to better capture the different exposure by age group:

$$CDI = \frac{EPC \times IR \times FI \times EF \times CF}{AT} \times \left(\frac{ED_1}{BW_1} + \frac{ED_2}{BW_2} + \frac{ED_3}{BW_3} + \frac{ED_4}{BW_4} + \frac{ED_5}{BW_5} + \frac{ED_6}{BW_6} \right)$$

^b Different body weights were used for each 1-year age class to reflect the increasing body weight during this age range. Average weights for boys and girls are as follows (EPA 2008b):

Age Class	BW (kg)	Age Class	BW (kg)
< 1	9.1	3 – 4	15.3
1 – 2	11.3	4 – 5	17.4
2 – 3	13.3	5 – 6	19.7

CDI – chronic daily intake

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-16. Daily Intake Calculations – Dermal Contact with Soil or Sediment During Force Lake Recreation

Scenario timeframe: Current/future			
Exposure media: Lake sediment or wetland soil			
Exposure route: Dermal			
Intake equation: $CDI \text{ (mg/kg dw)} = EPC \times ABS \times AF \times SA \times FI \times EF \times ED \times CF \times 1/BW \times 1/AT$			
Parameter Code	Parameter Description	Value	Rationale and Reference
General			
EPC	exposure point concentration	na	COPC specific
ABS	dermal absorption fraction	na	COPC specific
AF	adherence factor by event (mg/cm ²)	0.2	EPA (2004)
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	22	based on the assumption that individuals visit the Study Area once per week during the summer (13 weeks) and once per month during the rest of the year (9 months) (Note that EPA guidance (2008b) recommends using site-specific values, which are not available for the Study Area.)
ED	total exposure duration (yrs)	30	EPA (1989)
CF	conversion factor	0.000001	conversion from mg to kg
AT_c	cancer averaging time (days)	25,550	EPA (1989)
AT_nc	non-cancer averaging time (days)	ED × 365	EPA (1989); equal to ED × 365 days
Adult (aged 17 to 30)			
SA_a	exposed skin surface area (cm ²)	5,800	95 th percentile for outdoor activity (EPA 1997; Table 6-16)
ED_a	exposure duration (yrs)	14	EPA (1989); 30 yrs minus child exposure durations
BW_a	body weight (kg)	70	default value (EPA 1989)
Older Child (aged 7 to 16)			
SA_co	exposed skin surface area (cm ²)	4,700	(EPA 2008b, Table 7-1), assuming 35% of the total surface area (EPA 1992a)
ED_co	exposure duration (yrs)	10	EPA (1991)
BW_co	body weight (kg)	44.3	(EPA 2008b, Table ES-1)
Young Child (aged 0 to 6)			
SA_c	exposed skin surface area (cm ²)	variable by age ^c	EPA (1997)
ED_c	exposure duration (yrs)	6 ^a	EPA (1991)
BW_c	body weight (kg)	variable by age ^b	EPA (2008b)

^a The total exposure duration was 6 years, but exposure was calculated in 1-year increments by age class (< 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6 years). For dermal absorption, Equation 3-3 was modified as follows to better capture the different exposure by age group:

$$CDI = \frac{EPC \times ABS \times FI \times EF \times CF}{AT} \times \left(\frac{ED_1 \times SA_1}{BW_1} + \frac{SA_2 \times ED_2}{BW_2} + \frac{SA_3 \times ED_3}{BW_3} + \frac{SA_4 \times ED_4}{BW_4} + \frac{SA_5 \times ED_5}{BW_5} + \frac{SA_6 \times ED_6}{BW_6} \right)$$

- ^b Different body weights and surface areas were used for each 1-year age class to reflect the increasing body weight during this age range. Average weights for boys and girls are as follows (EPA 2008b):

Age Class	BW (kg)	Age Class	BW (kg)
< 1	9.1	3 – 4	15.3
1 – 2	11.3	4 – 5	17.4
2 – 3	13.3	5 – 6	19.7

- ^c Skin surface area for children varies by age class. For the purpose of this scenario, children were assumed to be wearing a short-sleeve shirt, short pants, and no shoes (corresponding to approximately 35% of the total surface area) (EPA 1992a). Values shown are this fraction of the 50th percentile of surface areas for boys and girls in the following age classes (EPA 2008b):

Age Class	SA (cm ²)	Age Class	SA (cm ²)
< 1	1,330	3 – 4	2,298
1 – 2	1,750	4 – 5	2,515
2 – 3	2,069	5 – 6	2,751

CDI – chronic daily intake

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-17. Daily Intake Calculations – Incidental Ingestion of Surface Water During Force Lake Recreation

Scenario timeframe: Current/future			
Exposure media: Lake surface water			
Exposure route: Ingestion (incidental)			
Intake equation: CDI (mg/kg dw) = EPC × CR × ET × FI × EF × ED × CF × 1/BW × 1/AT			
Parameter Code	Parameter Description	Value	Rationale and Reference
General			
EPC	exposure point concentration	na	COPC specific
CR	contact rate (L/hr)	0.05	default value (EPA 1989)
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	22	based on the assumption that individuals visit the Study Area once per week during the summer (13 weeks) and once per month during the rest of the year (9 months) (Note that EPA guidance (2008b) recommends using site-specific values, which are not available for the Study Area.)
ED	total exposure duration (yrs)	30	EPA (1989)
AT_c	cancer averaging time (days)	25,550	EPA (1989)
AT_nc	non-cancer averaging time (days)	ED × 365	EPA (1989); equal to ED × 365 days
Adult (aged 17 to 30)			
ET_a	exposure time (hrs/day)	3.3	average time people spend outdoors at a park (EPA 1997; Table 5-109)
ED_a	exposure duration (yrs)	14	EPA (1989); 30 yrs minus child exposure durations
BW_a	body weight (kg)	70	default value (EPA 1989)
Older Child (aged 7 to 16)			
ET_co	exposure time (hrs/day)	2.35	average time children spend outdoors at a park (EPA 2008b, Table 16-37)
ED_co	exposure duration (yrs)	10	EPA (1991)
BW_co	body weight (kg)	44.3	(EPA 2008b, Table ES-1)
Young Child (aged 0 to 6)			
ET_c	exposure time (hrs/day)	1.7	average time children spend outdoors at a park (EPA 2008b, Table 16-37)
ED_c	exposure duration (yrs)	6 ^a	EPA (1991)
BW_c	body weight (kg)	variable by age ^b	EPA (2008b)

^a The total exposure duration was 6 years, but exposure was calculated in 1-year increments by age class (< 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6 years). For incidental ingestion, Equation 3-1 was modified as follows to better capture the different exposure by age group:

$$CDI = \frac{EPC \times IR \times FI \times EF \times CF}{AT} \times \left(\frac{ED_1}{BW_1} + \frac{ED_2}{BW_2} + \frac{ED_3}{BW_3} + \frac{ED_4}{BW_4} + \frac{ED_5}{BW_5} + \frac{ED_6}{BW_6} \right)$$

^b Different body weights were used for each 1-year age class to reflect the increasing body weight during this age range. Average weights for boys and girls were as follows (EPA 2008b):

Age Class	BW (kg)	Age Class	BW (kg)
< 1	9.1	3 – 4	15.3
1 – 2	11.3	4 – 5	17.4
2 – 3	13.3	5 – 6	19.7

CDI – chronic daily intake

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-18. Daily Intake Calculations – Dermal Contact with Surface Water During Force Lake Recreation

Scenario time frame: Current/future Exposure media: Lake surface water Exposure route: Dermal Intake equation: $CDI \text{ (mg/kg dw)} = DA_{\text{event}} \times SA \times EF \times EV \times ED \times 1/BW \times 1/AT$			
Parameter Code	Parameter Description	Value	Rationale and Reference
General			
DA_{event}	absorbed dose per event	na	COPC specific (see Equations 3-5 to 3-7)
EF	exposure frequency (d/yr)	22	based on the assumption that individuals visit the Study Area once per week during the summer (13 weeks) and once per month during the rest of the year (9 months) – one event per day (Note that EPA guidance (2008b) recommends using site-specific values, which are not available for the Study Area.)
EV	event frequency (events/day)	1	
ED	total exposure duration (yrs)	30	EPA (1989)
AT _c	cancer averaging time (days)	25,550	EPA (1989)
AT _{nc}	non-cancer averaging time (days)	$ED \times 365$	EPA (1989); equal to $ED \times 365$ days
FI ^a	fractional intake from site	1	assumes 100% exposure to site
Adult (aged 17 to 30)			
SA _a	exposed skin surface area (cm ²)	5,800	95 th percentile for outdoor activity (EPA 1997; Table 6-16)
ED _a	exposure duration (yrs)	14	EPA (1989); 30 yrs minus child exposure durations
BW _a	body weight (kg)	70	default value (EPA 1989)
ET _a ^a	exposure time (hrs/day)	3.3	average time people spend outdoors at a park (EPA 1997; Table 5-109)
Older Child (aged 7 to 16)			
SA _{co}	exposed skin surface area (cm ²)	4,700	(EPA 2008b, Table 7-1), assuming 35% of the total surface area (EPA 1992a)
ED _{co}	exposure duration (yrs)	10	EPA (1991)
BW _{co}	body weight (kg)	44.3	(EPA 2008b, Table ES-1)
ET _{co} ^a	exposure time (hrs/day)	2.35	average time children spend outdoors at a park (EPA 2006a, Table 9-67)
Young Child (aged 0 to 6)			
SA _c	exposed skin surface area (cm ²)	variable by age ^d	EPA (1997)
ED _c	exposure duration (yrs)	6 ^b	EPA (1991)
BW _c	body weight (kg)	variable by age ^c	EPA (2008b)
ET _c ^a	exposure time (hrs/day)	1.7	average time children spend outdoors at a park (EPA 2006a, Table 9-67)

^a These parameters were not listed in the CDI equation shown in this table, but were scenario-specific parameters needed to calculate the absorbed dose per event (DA_{event}).

- ^b The total exposure duration was 6 years, but exposure was calculated in 1-year increments by age class (< 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6 years). For incidental ingestion, Equation 3-4 was modified as follows to better capture the different exposure by age group:

$$CDI = \frac{EPC \times IR \times FI \times EF \times CF}{AT} \times \left(\frac{ED_1}{BW_1} + \frac{ED_2}{BW_2} + \frac{ED_3}{BW_3} + \frac{ED_4}{BW_4} + \frac{ED_5}{BW_5} + \frac{ED_6}{BW_6} \right)$$

- ^c Different body weights were used for each 1-year age class to reflect the increasing body weight during this age range. Average weights for boys and girls were as follows (EPA 2008b):

Age Class	BW (kg)	Age Class	BW (kg)
< 1	9.1	3 – 4	15.3
1 – 2	11.3	4 – 5	17.4
2 – 3	13.3	5 – 6	19.7

- ^d Skin surface area for children varies by age class. For the purpose of this scenario, children were assumed to be wearing a short-sleeve shirt, short pants, and no shoes (corresponding to approximately 35% of the total surface area) (EPA 1992a). Values shown are this fraction of the 50th percentile of surface areas for boys and girls in the following age classes (EPA 2008b):

Age Class	SA (cm ²)	Age Class	SA (cm ²)
< 1	1,330	3 – 4	2,298
1 – 2	1,750	4 – 5	2,515
2 – 3	2,069	5 – 6	2,751

CDI – chronic daily intake

dw – dry weight

EPA – US Environmental Protection Agency

na – not applicable

Table 3-19. Daily Intake Calculations – Consumption of Fish Tissue from Force Lake

Scenario timeframe: Current/future			
Exposure media: Calculated Force Lake fish tissue			
Exposure route: Ingestion			
Intake equation: CDI (mg/kg dw) = EPC × IR-f × FI × EF × ED × CF × 1/BW × 1/AT			
Parameter Code	Parameter Description	Value	Rationale and Reference
General			
EPC	exposure point concentration (mg/kg ww)	na	COPC specific
FI	fractional intake from site	1	assumes 100% exposure to site
EF	exposure frequency (d/yr)	365	ingestion rate calculated based on 365 days per year
ED	total exposure duration (yrs)	30	EPA (1989)
CF	conversion factor	0.001	conversion from kg to g
AT_c	cancer averaging time (days)	25,550	EPA (1989)
AT_nc	non-cancer averaging time (days)	ED × 365	EPA (1989); equal to ED × 365 days
Adult (aged 17 to 30)			
IR-f_a	fish ingestion rate (g/day)	3.75	assumes the consumption of six meals per year from Force Lake ^a (see Section 3.3.3)
ED_a	exposure duration (yrs)	14	EPA (1989); 30 yrs minus child exposure durations
BW_a	body weight (kg)	70	default value (EPA 1989)
Older Child (aged 7 to 16)			
IR-f_co	fish ingestion rate (g/day)	1.63	assumes the consumption of six meals per year from Force Lake with a meal size equal to 99 g ^b (see Section 3.3.3)
ED_co	exposure duration (yrs)	10	EPA (1991)
BW_co	body weight (kg)	44.3	(EPA 2008b, Table ES-1)
Young Child (aged 0 to 6)			
IR-f_c	fish ingestion rate (g/day)	1.05	assumes the consumption of six meals per year from Force Lake with a meal size equal to 64 g ^b (see Section 3.3.3)
ED_c	exposure duration (yrs)	6 ^c	EPA (1991)
BW_c	body weight (kg)	variable by age ^d	EPA (2008b)

^a Adult meal size was assumed to be 8 oz or 228 g.

^b The older child meal size of 99 g was based on the average finfish meal size for children 6 to 19 years of age and the young child meal size of 64 g was based on the average finfish meal size for children 2 to 5 years of age, as reported in Table 10-28 of EPA's *Child-Specific Exposure Factors Handbook* (2008b).

^c The total exposure duration was 6 years, but exposure was calculated in 1-year increments by age class (< 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6 years). For incidental ingestion, Equation 3-4 was modified as follows to better capture the different exposure by age group:

$$CDI = \frac{EPC \times IR \times FI \times EF \times CF}{AT} \times \left(\frac{ED_1}{BW_1} + \frac{ED_2}{BW_2} + \frac{ED_3}{BW_3} + \frac{ED_4}{BW_4} + \frac{ED_5}{BW_5} + \frac{ED_6}{BW_6} \right)$$

- ^d Different body weights were used for each 1-year age class to reflect the increasing body weight during this age range. Average weights for boys and girls were as follows (EPA 2008b):

Age Class	BW (kg)	Age Class	BW (kg)
< 1	9.1	3 – 4	15.3
1 – 2	11.3	4 – 5	17.4
2 – 3	13.3	5 – 6	19.7

CDI – chronic daily intake

dw – dry weight

EPA – US Environmental Protection Agency

ww – wet weight

na – not applicable

3.3.3 Fish Consumption Rate

At the direction of EPA in comments on the risk assessment scoping memorandum (EPA 2008c), a fish consumer scenario was developed as part of this baseline HHRA. To assess the level of fishing that may be occurring at Force Lake, site-specific information was gathered regarding the fish population present in the lake and the use of the lake by anglers. The following subsections provide a rationale for selection of a fish consumption rate of six meals per year (one meal per month during the warmer months) as a conservative fish ingestion rate for purposes of the risk assessment.

3.3.3.1 April 2009 Force Lake Fish Survey

A survey of the fish population in Force Lake was conducted on Tuesday, April 7, 2009, to obtain information on the types of fish that are present in the lake and estimate the abundance and sizes of these fish (Windward 2009b). The survey was conducted in accordance with the fish survey sampling design memorandum approved by EPA (Windward 2009a) and used several collection methods under good conditions⁹ to provide a representative picture of the fish population present in Force Lake.

A total of 88 fish were collected, approximately 86% of which were 14 cm (5.5 inches) in length or less. Only 12 fish (all carp) greater than this size were caught, 10 of which were in the 15 to 20 cm range (5.9 to 7.9 inches), and 2 of which were in the 20 to 25 cm range (7.9 to 9.8 inches). Additionally, one or two larger carp were observed during the survey but were not captured (i.e., they were not fully stunned and were able to escape), as discussed by Windward (2009b).

The electrofishing results and the types of fish caught in Force Lake were consistent with the expected population of a small, shallow lake with no riparian cover, such as Force Lake. In lakes of this type, the fishery is generally stunted as a result of the available habitat, meaning that most of the fish would be small in size because of the intense competition for food. The competition is magnified by the lack of large predator fish, which would otherwise tend to reduce the population numbers of forage fish. Only carp (all less than 22 cm), pumpkinseed (all less than 12 cm), and one small brown bullhead (6.7 cm) were caught, none of which are native to the region. No game fish (e.g., trout or bass) were observed during the survey. The 2009 survey results were consistent with the results of an earlier survey conducted in the late 1980s (Fishman 1989), during which a similarly low number of larger fish were caught (only four large carp [30 cm or greater in length] and at least two large bullhead [25 cm or greater in length]). Thus, the results of the 2009 survey support the conclusion that there is a small population of carp in Force Lake and a stunted pumpkinseed fishery, largely because of the limited habitat in Force Lake.

⁹ Lake conditions conducive to an optimal catch per unit effort during the fish survey included a moderate water temperature, good water clarity, shallow water depth, and lack of habitat to provide cover for the fish.

Additionally, information regarding past fish kills in Force Lake may help explain the fish population observed during the 2009 survey. Jesse Goodling, the Heron Lakes Golf Course Superintendent, noted that since 1986, when he started working at the golf course, the water level in Force Lake during at least two different years was low enough to expose part of the lake bottom, typically at the end of a hot, dry summer. The last time this happened (4 or 5 years ago), Mr. Goodling recalled seeing a number of dead fish floating in the lake, possibly because of an algae bloom, which would have depressed oxygen levels in Force Lake (Goodling 2009). This type of event is another indicator supporting the 2009 Survey results, which suggest the presence of a relatively small fish population with few fish species.

3.3.3.2 Study Area-Specific Information Regarding Fishing at Force Lake

Information regarding the extent of fishing that occurs at Force Lake is available in the Harbor Oil Public Health Assessment conducted by the Oregon Department of Human Services (ODHS) (2004). This report assessed the potential for unacceptable risks to people based on consumption of fish from Force Lake. As part of this effort, a small survey of residents from the surrounding neighborhoods was conducted (n = 12). Only 3 respondents had seen or heard of people fishing at Force Lake, indicating that limited fishing is occurring. ODHS recommended in the report that signs be posted around the lake to warn people about potentially unacceptable risks associated with fish consumption, but that recommendation was not based on an assessment of fish tissue data from Force Lake.

3.3.3.3 Selected Fish Consumption Rate

Based on the information presented here, a fish consumption rate of 1 meal per month during the spring and summer months (April to September) is assumed for the Force Lake fish consumer RME scenario. This fishing scenario assesses risks to individuals who eat the equivalent of six meals per year of fish caught in Force Lake. This scenario is intended to assess risks to either recreational anglers, ethnic populations using fish collected from Force Lake to supplement their diet, or transient individuals collecting several meals from Force Lake as they move around the area. Note that individuals who collect fish from Force Lake may also collect fish from other nearby water bodies (e.g., those throughout the Columbia Slough).

This consumption rate is based on best professional judgment using the information presented above regarding the fish population in Force Lake and information regarding fishing frequency.

Table 3-20 presents the numbers of fish that would be required to support six anglers¹⁰ who each ate six meals per year, compared to the number of fish caught during the 2009 survey.

Table 3-20. Hypothetical Fish Catch Rates for Six Anglers Consuming Six Meals per Year from Force Lake

Fish Size Category	No. of Fish Collected During the 2009 Survey	Annual No. of Fish Needed for Six Anglers (six meals per year)	
		Adults Only ^a	Adults and Children ^b
Small fish (less than 15 cm in length)	77	360 to 540	461 to 691
Medium-sized fish (15 to 25 cm in length)	12	72 to 108	92 to 138
Large fish (over 50 cm in length)	1 to 2 ^c	36	46

^a One meal (8 oz or 228 g) was assumed to be equal to either 1 large fish (over 50 cm in length), 2 to 3 medium-sized fish (15 to 25 cm in length), or 10 to 15 small fish (less than 15 cm in length). For example, for one angler to eat six meals per year of medium-sized fish from Force Lake it would require that 12 to 18 fish be caught each year (i.e., 2 to 3 times 6). Thus, for six anglers to eat at this rate, a total of 72 to 108 medium-sized fish would need to be caught each year (i.e., 12 to 18 times 6).

^b This scenario assumes each adult catching fish from Force Lake is also feeding one young child. The meal size for children was assumed to be equal to 64 g/meal, based on the average meal size of finfish consumed by children aged 2 to 5 from EPA's *Child-Specific Exposure Factors Handbook* (EPA 2008b; Table 10-28).

^c The large fish (carp) were observed during the fish survey but were not captured.

The Force Lake fish survey was not designed to estimate the total number of fish in the lake. However, given the methods that were used, the conditions under which the survey was conducted, and the extensive electrofishing effort, the survey effort was sufficient to conclude reliably that the lake contains a relatively small population of fish, especially compared to the numbers of fish that would be needed to support fishing at the rate proposed (Table 3-20). In order for six anglers to catch enough fish to eat six meals per year of fish from Force Lake, 5 to 10 times the number of fish observed during the Force Lake survey would need to be caught by these anglers every year to feed six adults. If each of these adults was assumed to also be feeding a child fish from Force Lake, 6 to 11 times the number of fish observed during the Force Lake survey would need to be caught by these anglers every year. Thus, the survey results indicate that the proposed consumption rate of six meals per year is conservative (Table 3-20).

¹⁰ This evaluation was done assuming six anglers because Jesse Goodling, Heron Lakes Golf Course Superintendent, reported seeing five to six people fishing at Force Lake during the summer months (Goodling 2008).

3.3.4 Dermal Absorption Fractions

Sediment and soil exposure scenarios were developed in Section 3.3 for workers and recreational users. For those scenarios that include dermal exposure to soil or sediment, most of the exposure parameters relative to this exposure routes are provided in Tables 3-8 to 3-19. This section discusses the COPC-specific dermal absorption fraction (ABS) and the oral adjustment factor. The ABS is multiplied by the exposure dose for the dermal pathway (as shown in Tables 3-8 to 3-19) and refers to the fraction of the COPC in sediment applied to the skin surface that is absorbed into the bloodstream. The oral adjustment factor is used to convert the administered/external dose to an absorbed/internal dose (as shown in Table 3-21) to account for the increased potency of the absorbed dose as compared with the ingested dose because of incomplete absorption across the gastrointestinal tract (EPA 2004).

Many studies have focused on the topic of chemical-specific dermal absorption, but there is considerable uncertainty regarding chemical-specific values (EPA 1992a). EPA (2004) has developed supplemental guidance for dermal risk assessment that provides ABS values for most of the organic COPCs but provides ABS values for only two metal COPCs (arsenic and cadmium) and no volatile organic compounds (VOCs) (Table 3-21). With regard to metals, the guidance document (EPA 2004) states that the speciation of inorganic substances is crucial to estimating dermal absorption, and data are insufficient to derive default values for other inorganic substances. Older EPA guidance (2001) on dermal absorption provided a general value of 0.01 for all metals, reflecting a generally low dermal absorption of metals. With regard to VOCs, the guidance document stated that VOCs would likely volatilize from the soil adhering to skin, and should instead be accounted for via inhalation routes.

Risks based on dermal exposure were not quantified for COPCs for which specific ABS were not provided (EPA 2004, Exhibit 3-4). As suggested in the guidance documents (EPA 2004), the potential health risks from dermal exposure to these COPCs is evaluated further in the uncertainty analysis (Section 6.0).

In this assessment, cadmium was the only COPC with both a recommended dermal absorption factor and reduced oral absorption. However, cadmium was a COPC only for the fish consumption pathway and thus was not evaluated based on dermal exposure.

For other COPCs lacking an ABS, no dermal absorption was assumed for the risk characterization; and therefore, the reference dose (RfD) adjustment was not relevant. Alternative dermal absorption assumptions for exposure through direct sediment contact for COPCs without an ABS are explored in the uncertainty analysis.

Table 3-21. Dermal Absorption Fractions

COPC	ABS (unitless)^a	Oral Absorption Adjustment^b
Metals		
Aluminum	none	none
Antimony	none	RfD multiplied by 0.15
Arsenic	0.03	none
Barium	none	RfD multiplied by 0.07
Cadmium	0.001	RfD multiplied by 0.025
Chromium	none	RfD multiplied by 0.025
Cobalt	none	none
Copper	none	none
Iron	none	none
Lead	none	none
Manganese	none	RfD multiplied by 0.04
Mercury	none	RfD multiplied by 0.07
Nickel	none	RfD multiplied by 0.04
Vanadium	none	RfD multiplied by 0.026
Zinc	none	none
PAHs		
Naphthalene	0.13	none
cPAH TEQ	0.13	none
Other SVOCs		
1,4-Dichlorobenzene	0.1	none
PCBs		
Total PCBs	0.14	none
Pesticides		
Total DDTs	0.03	none
VOCs		
1,1-Dichloroethane	none	none
1,2,4-Trimethylbenzene	none	none
1,3,5-Trimethylbenzene	none	none
Benzene	none	none
Chlorobenzene	none	none
cis-1,2-Dichloroethene	none	none
Dichloromethane	none	none
Ethylbenzene	none	none
n-Propylbenzene	none	none
tert-Butyl methyl ether	none	none
trans-1,2-Dichloroethene	none	none
Trichloroethene	none	none

Table 3-21. Dermal Absorption Fractions

COPC	ABS (unitless)^a	Oral Absorption Adjustment^b
Vinyl chloride	none	none
Total xylenes	none	none

Source: RAGS Part E (EPA 2004)

^a The ABS values are presented in Exhibit 3-4 of EPA (2004).

^b The oral adjustment values are presented in Exhibit 4-1 of EPA (2004).

ABS – dermal absorption fraction

RAGS – Risk Assessment Guidance for Superfund

cPAH – carcinogenic polycyclic aromatic hydrocarbon

RfD – reference dose

DDT – dichlorodiphenyltrichloroethane

SVOC – semivolatile organic compound

EPA – US Environmental Protection Agency

TEQ – toxic equivalent

PAH – polycyclic aromatic hydrocarbon

VOC – volatile organic compound

PCB – polychlorinated biphenyl

3.3.5 Calculation of Exposure Concentrations

EPCs were calculated to represent exposure concentrations for the risk estimates. In accordance with EPA guidance (1989), the EPC is defined as the average concentration contacted at the exposure point(s) over the duration of the exposure period. EPA recommends using the average concentration to represent "a reasonable estimate of the concentration likely to be contacted over time" (EPA 1989). Use of the average concentration is also consistent with EPA toxicity criteria, which are based on lifetime average exposures. Because it is generally not possible to know the true average, the 95% upper confidence limit on the mean (UCL) is typically used in CERCLA risk assessments to represent the average concentration. The UCL is defined as a value that, when calculated repeatedly for randomly drawn subsets of data, equals or exceeds the mean of the true population 95% of the time. Using a UCL can also help account for uncertainties associated with a limited number of samples and an uneven spatial distribution of contaminant concentrations. If sufficient data (i.e., six or more detected concentrations) were available, UCLs were calculated using ProUCL 4.00.04, which includes provisions for handling non-detected values (EPA 2009e). The UCL recommended by ProUCL was used as the EPC for the risk assessment.

If insufficient data were available to calculate a UCL using ProUCL, the EPC was set equal to the higher of either the maximum detected value or one-half of the maximum RL. When fewer than six detected values are available, the UCL may not provide a reliable estimate of the true mean concentration, particularly if the dataset is positively skewed, as is often the case with environmental sampling. When the number of samples used to characterize an exposure area is very small (e.g., $n < 6$), there is substantial uncertainty associated with any estimate of the mean concentration. Thus, per EPA guidance (2009e), a maximum value is selected in an attempt to avoid underestimating the true mean for the dataset.

Summary statistics and EPCs for the all COPCs identified in Section 3.2 are presented in Table 3-22. In addition, Table 3-23 provides a summary of these EPCs to aid in comparison across scenarios. In addition, data tables, ProUCL input files, and ProUCL output data tables are presented as an electronic supplement to Attachment 5.

Table 3-22. Exposure Point Concentrations and Summary Statistics for the Baseline HHRA

COPC	Unit	Detection Frequency (ratio)	Maximum Detection	Maximum RL	Mean Detect	Mean Value ^a	KM Mean ^b	EPC	Selected Statistic
Industrial (Construction/Trenching) Worker: Facility Soil									
Arsenic	mg/kg dw	112/112	53.1	na	5	5	na	8.3	95% Chebyshev (mean, SD) UCL
Cobalt	mg/kg dw	112/112	35 J	na	10	10	na	13	95% approximate gamma UCL
Copper	mg/kg dw	112/112	1,370	na	100	100	na	270	97.5% Chebyshev (mean, SD) UCL
Lead ^c	mg/kg dw	112/112	337	na	40	40	na	77	97.5% Chebyshev (mean, SD) UCL
Naphthalene	µg/kg dw	85/115	19,000	242 U	920	680	680	2,000	97.5% KM (Chebyshev) UCL
cPAH TEQ	µg/kg dw	106/115	5,200	637 U	506	473	470	950	97.5% KM (Chebyshev) UCL
Total PCBs	µg/kg dw	74/114	32,000	200 U	2,000	1,000	1,200	3,400	97.5% KM (Chebyshev) UCL
Total DDTs	µg/kg dw	104/115	78,000 J	130 U	5,000	4,000	4,200	11,000	97.5% KM (Chebyshev) UCL
1,1-Dichloroethane	µg/kg dw	4/113	680	1,100 U	170	20	na	680	maximum detect
1,2,4-Trimethylbenzene	µg/kg dw	49/95	40,000	7.1 UJ	3,000	1,000	1,300	5,300	97.5% KM (Chebyshev) UCL
1,3,5-Trimethylbenzene	µg/kg dw	34/95	12,000	120 U	800	300	300	1,300	97.5% KM (Chebyshev) UCL
Benzene	µg/kg dw	52/113	6,400	810 U	170	90	78	330	95% KM (Chebyshev) UCL
Chlorobenzene	µg/kg dw	24/113	2,900 J	1,100 U	200	60	46	220	97.5% KM (Chebyshev) UCL
cis-1,2-Dichloroethene	µg/kg dw	10/113	130,000	1,100 U	13,000	1,000	1,200	8,700	97.5% KM (Chebyshev) UCL
Dichloromethane	µg/kg dw	27/113	370	2,200 U	31	43	9.6	20	95% KM (BCA) UCL
Ethylbenzene	µg/kg dw	35/113	26,000	120 U	1,200	400	390	1,900	97.5% KM (Chebyshev) UCL
trans-1,2-Dichloroethene	µg/kg dw	1/95	5,500	1,100 U	5,500	70	na	5,500	maximum detect
Trichloroethene	µg/kg dw	9/113	2,400	1,100 U	270	40	23	160	97.5% KM (Chebyshev) UCL
Vinyl chloride	µg/kg dw	2/113	1,200	1,100 U	610	30	na	1,200	maximum detect
Total xylenes	µg/kg dw	53/113	150,000 J	380 U	4,000	2,000	1,800	10,000	97.5% KM (Chebyshev) UCL
TPH-gasoline (aliphatic) ^d	mg/kg dw	49 / 97	3,230	48 U	270	140	140	430	97.5% KM (Chebyshev) UCL
Industrial (Construction/Trenching) Worker: Groundwater									
Arsenic (total) ^e	µg/L	28/28	31.6	na	10	10	na	15	95% Student's-t UCL
Lead (total) ^c	µg/L	8/28	19.6	1 U	5	2	1.7	3	95% KM (t) UCL

Table 3-22. Exposure Point Concentrations and Summary Statistics for the Baseline HHRA

COPC	Unit	Detection Frequency (ratio)	Maximum Detection	Maximum RL	Mean Detect	Mean Value ^a	KM Mean ^b	EPC	Selected Statistic
Manganese (total) ^e	µg/L	28/28	7,860	na	3,400	3,400	na	4,000	95% Student's-t UCL
Naphthalene	µg/L	7/28	1.5	0.4 U	0.47	0.2	0.19	0.33	95% KM (BCA) UCL
1,4-Dichlorobenzene	µg/L	4/28	1.4	1 U	0.8	0.5	na	1.4	maximum detect
Total DDTs	µg/L	12/28	0.24 J	0.019 U	0.063	0.030	0.031	0.049	95% KM (t) UCL
1,2,4-Trimethylbenzene	µg/L	2/22	7.2	1.0 U	5.5	0.91	na	7.2	maximum detect
1,3,5-Trimethylbenzene	µg/L	3/22	3.0	1.0 U	2.3	0.71	na	3	maximum detect
Benzene	µg/L	8/28	140	6.2 U	20	6	6.3	39	97.5% KM (Chebyshev) UCL
Chlorobenzene	µg/L	15/28	130	1 U	30	10	14	80	99% KM (Chebyshev) UCL
n-Propylbenzene	µg/L	4/22	11	1.0 U	5.3	1.3	na	11	maximum detect
tert-Butyl methyl ether	µg/L	14/28	160	1 U	30	10	14	28	95% KM (BCA) UCL
Vinyl chloride	µg/L	1/28	0.22 J	1 U	0.22	0.4	na	0.5	half maximum RL
Future Outdoor Worker: Facility Soil									
Arsenic	mg/kg dw	69/69	53.1	na	6	6	na	11	95% Chebyshev (mean, SD) UCL
Cobalt	mg/kg dw	69/69	32	na	10	10	na	14	95% Student's-t UCL
Copper	mg/kg dw	69/69	1,240 J	na	100	100	na	150	95% H-UCL
Lead ^c	mg/kg dw	69/69	337	na	60	60	na	71	95% approximate gamma UCL
Naphthalene	µg/kg dw	52/73	19,000	242 U	1,000	750	740	2,600	97.5% KM (Chebyshev) UCL
cPAH TEQ	µg/kg dw	69/73	5,200	450 U	645	617	610	1,100	95% KM (Chebyshev) UCL
Total PCBs	µg/kg dw	59/71	32,000	160 U	2,000	2,000	1,800	5,200	97.5% KM (Chebyshev) UCL
Total DDTs	µg/kg dw	68/72	78,000 J	130 U	6,000	6,000	6,100	16,000	97.5% KM (Chebyshev) UCL
1,1-Dichloroethane	µg/kg dw	3/69	680	1,100 U	230	30	na	680	maximum detect
1,2,4-Trimethylbenzene	µg/kg dw	24/54	40,000	7.1 UJ	4,000	2,000	1,900	13,000	99% KM (Chebyshev) UCL
1,3,5-Trimethylbenzene	µg/kg dw	18/54	12,000	120 U	1,000	400	380	3,000	99% KM (Chebyshev) UCL
Benzene	µg/kg dw	25/69	6,400	810 U	280	100	100	510	95% KM (Chebyshev) UCL
cis-1,2-Dichloroethene	µg/kg dw	4/69	130,000	1,100 U	33,000	2,000	na	130,000	maximum detect

Table 3-22. Exposure Point Concentrations and Summary Statistics for the Baseline HHRA

COPC	Unit	Detection Frequency (ratio)	Maximum Detection	Maximum RL	Mean Detect	Mean Value ^a	KM Mean ^b	EPC	Selected Statistic
Dichloromethane	µg/kg dw	18/69	370	2,200 U	44	47	13	47	95% KM (Chebyshev) UCL
Ethylbenzene	µg/kg dw	19/69	26,000	120 U	2,000	600	550	3,100	97.5% KM (Chebyshev) UCL
trans-1,2-Dichloroethene	µg/kg dw	1/54	5,500	1,100 U	5,500	100	na	5,500	maximum detect
Trichloroethene	µg/kg dw	6/69	2,400	1,100 U	400	50	36	270	97.5% KM (Chebyshev) UCL
Vinyl chloride	µg/kg dw	1/69	1,200	1,100 U	1,200	30	na	1,200	maximum detect
Total xylenes	µg/kg dw	29/69	150,000 J	83 U	6,000	3,000	2,600	16,000	97.5% KM (Chebyshev) UCL
TPH-gasoline (aliphatic) ^d	mg/kg dw	28/56	3,230	48 U	330	170	170	660	97.5% KM (Chebyshev) UCL
Industrial/Commercial Worker Vapor Intrusion Scenario: Groundwater									
Benzene	µg/L	2/6	2.9	6.2 U	2.6	2	na	3.1	half maximum RL
Vinyl chloride	µg/L	1/6	0.22 J	1 U	0.22	0.5	na	0.5	half maximum RL
Force Lake Recreational User: Wetland Soil									
Aluminum	mg/kg dw	5/5	12,100	na	9,500	9,500	na	12,000	maximum detect
Antimony	mg/kg dw	7/61	8.4 J	4.5 U	2	0.5	0.84	1.1	95% KM (% Bootstrap) UCL
Arsenic	mg/kg dw	61/61	53.1	na	8	8	na	9.6	95% H-UCL
Chromium	mg/kg dw	61/61	149	na	30	30	na	37	95% H-UCL
Cobalt	mg/kg dw	61/61	34.3	na	10	10	na	12	95% Modified-t UCL
Copper	mg/kg dw	61/61	1,240 J	na	77	77	na	160	95% Chebyshev (mean, SD) UCL
Iron	mg/kg dw	5/5	56,500	na	29,500	29,500	na	57,000	maximum detect
Lead ^c	mg/kg dw	61/61	320	na	60	60	na	80	95% H-UCL
Manganese	mg/kg dw	5/5	1,090	na	724	724	na	1,100	maximum detect
Vanadium	mg/kg dw	61/61	148	na	70	70	na	76	95% approximate gamma UCL
Naphthalene	µg/kg dw	55/61	4,210	277 U	210	200	190	640	97.5% KM (Chebyshev) UCL
cPAH TEQ	µg/kg dw	59/61	5,200	888 U	478	475	470	1,100	95% KM (Chebyshev) UCL
Total PCBs	µg/kg dw	40/61	4,200	990 U	500	400	770	770	95% KM (Chebyshev) UCL
Total DDTs	µg/kg dw	60/61	46,000	130 U	3,000	3,000	2,500	9,100	97.5% KM (Chebyshev) UCL

Table 3-22. Exposure Point Concentrations and Summary Statistics for the Baseline HHRA

COPC	Unit	Detection Frequency (ratio)	Maximum Detection	Maximum RL	Mean Detect	Mean Value ^a	KM Mean ^b	EPC	Selected Statistic
Benzene	µg/kg dw	24/52	56	15 U	9.6	5	5.3	7.7	95% KM (t) UCL
Trichloroethene	µg/kg dw	2/52	4.7	15 U	3.6	2	na	7.5	half maximum RL
TPH-gasoline (aliphatic) ^d	mg/kg dw	4/56	17	49 U	12	8.4	na	25	half maximum RL
TPH-diesel (aliphatic) ^d	mg/kg dw	54/60	3,400	25 U	320	290	290	780	97.5% KM (Chebyshev) UCL
Force Lake Recreational User: Lake Sediment									
Arsenic	mg/kg dw	11/11	7	na	6	6	na	6.4	95% Student's-t UCL
Chromium	mg/kg dw	11/11	34	na	30	30	na	30	95% Student's-t UCL
Cobalt	mg/kg dw	11/11	15	na	13	13	na	14	95% Student's-t UCL
Lead ^c	mg/kg dw	11/11	56	na	40	40	na	62	95% Chebyshev (mean, SD) UCL
Vanadium	mg/kg dw	11/11	74	na	60	60	na	67	95% Student's-t UCL
cPAH TEQ	µg/kg dw	11/11	118	na	61.9	61.9	na	81	95% Student's-t UCL
TPH-gasoline (aliphatic) ^d	mg/kg dw	1/11	26	68 U	26	24	na	34	half maximum RL
Force Lake Recreational User: Lake Surface Water									
Arsenic (total) ^e	µg/L	3/3	1.2	na	1.2	1.2	na	1.2	maximum detect
Force Lake Fish Consumer: Fish Tissue^f									
Arsenic	mg/kg ww	11/11	0.24	na	0.19	0.19	na	0.22	95% Student's-t UCL
Barium	mg/kg ww	11/11	62	na	53	53	na	57	95% Student's-t UCL
Cadmium	mg/kg ww	8/11	0.44	0.09 U	0.44	0.34	na	0.44	maximum detect ^g
Cobalt	mg/kg ww	11/11	4.2	na	3.5	3.5	na	3.9	95% Student's-t UCL
Copper	mg/kg ww	11/11	20	na	15	15	na	22	Use 95% Chebyshev (mean, SD) UCL
Lead ^c	mg/kg ww	11/11	2.8	na	2.0	2.0	na	3.1	95% Chebyshev (mean, SD) UCL
Mercury	mg/kg ww	1/11	0.021	0.021 U	0.021	0.017	na	0.021	maximum detect
Nickel	mg/kg ww	11/11	8.7	na	6.7	6.7	na	7.7	95% Student's-t UCL
Vanadium	mg/kg ww	11/11	21	na	17	17	na	19	95% Student's-t UCL
Zinc	mg/kg ww	11/11	120	na	89	89	na	100	95% Student's-t UCL

Table 3-22. Exposure Point Concentrations and Summary Statistics for the Baseline HHRA

COPC	Unit	Detection Frequency (ratio)	Maximum Detection	Maximum RL	Mean Detect	Mean Value ^a	KM Mean ^b	EPC	Selected Statistic
Total PCBs	mg/kg ww	7/11	0.44	0.29 U	0.32	0.26	0.29	0.33	95% KM (percentile bootstrap) UCL
Total DDTs	mg/kg ww	11/11	0.41	na	0.25	0.25	na	0.30	95% Student's-t UCL

^a The mean value is equal to the average of all detected values and one-half of the RL for all non-detect values.

^b The KM mean is calculated in ProUCL for datasets with a mix of detected and non-detected data. As with UCL calculations discussed at the beginning of this section, KM means can only be calculated for datasets with 6 or more detected values.

^c Lead is included in this table because it was designated as a COPC. However, risks associated with lead were evaluated separately, as discussed in Section B.3.3.6, using the IEUBK and the ALM for characterizing risks associated with adult lead exposure. As discussed in Section 3.3.6, mean concentrations, rather than UCL values, were used for lead modeling.

^d As discussed in Section 2.2.5, aliphatic TPH fractions were assumed to be equal to 85% of each TPH fraction based on ATSDR (1999).

^e Both the total and dissolved fraction of this COPC were greater than the screening level. As a conservative assumption, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

^f Fish tissue concentrations were calculated from lake sediment concentrations using BSAFs (see Attachment 2).

^g All detected values were equal, and thus there were too few unique values for the calculation of a UCL in ProUCL. The detected concentration was used as the EPC.

ALM – Adult Lead Model

BCA – bias-corrected accelerated

BSAF – biota-sediment accumulation factor

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EPA – US Environmental Protection Agency

EPC – exposure point concentration

HHRA – human health risk assessment

H-UCL – UCL based on Land's H-statistic

IEUBK – Integrated Exposure Uptake Biokinetic Model for Lead in Children

J – estimated concentration

KM – Kaplan-Meier

na – not applicable

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

SD – standard deviation

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

U – not detected at given concentration

UCL – upper confidence limit on the mean

ww – wet weight

Table 3-23. Summary of EPCs Used in Baseline HHRA

COPC	Fish Tissue (mg/kg ww)	Facility Soil (mg/kg dw) ^a		Wetland Soil (mg/kg dw)	Lake Sediment (mg/kg dw)	Groundwater (µg/L) ^b		Lake Water (µg/L)
	Force Lake Fish Consumer	Industrial (Construction/ Trenching) Worker	Future Outdoor Worker	Force Lake Recreational User	Force Lake Recreational User	Industrial (Construction/ Trenching) Worker	Industrial/ Commercial Worker	Force Lake Recreational User
Metals								
Aluminum	na	na	na	12,000	na	na	na	na
Antimony	na	na	na	1.1	na	na	na	na
Arsenic	0.22	8.3	11	9.6	6.4	15	na	1.2
Barium	57	na	na	na	na	na	na	na
Cadmium	0.44	na	na	na	na	na	na	na
Chromium	na	na	na	37	30	na	na	na
Cobalt	3.9	13	14	12	14	na	na	na
Copper	22	270	150	160	na	na	na	na
Iron	na	na	na	57,000	na	na	na	na
Lead ^b	3.1	77	71	80	62	3	na	na
Manganese	na	na	na	1100	na	4,000	na	na
Mercury	0.021	na	na	na	na	na	na	na
Nickel	7.7	na	na	na	na	na	na	na
Vanadium	19	na	na	76	67	na	na	na
Zinc	100	na	na	na	na	na	na	na
PAHs								
Naphthalene	na	2.0	2.6	0.64	na	0.33	na	na
cPAH TEQ	na	0.95	1.1	1.1	0.081	na	na	na
Other SVOCs								
1,4-Dichlorobenzene	na	na	na	na	na	1.4	na	na
PCBs								
Total PCBs	0.33	3.4	5.2	0.77	na	na	na	na

Table 3-23. Summary of EPCs Used in Baseline HHRA

COPC	Fish Tissue (mg/kg ww)	Facility Soil (mg/kg dw) ^a		Wetland Soil (mg/kg dw)	Lake Sediment (mg/kg dw)	Groundwater (µg/L) ^b		Lake Water (µg/L)
	Force Lake Fish Consumer	Industrial (Construction/ Trenching) Worker	Future Outdoor Worker	Force Lake Recreational User	Force Lake Recreational User	Industrial (Construction/ Trenching) Worker	Industrial/ Commercial Worker	Force Lake Recreational User
Pesticides								
Total DDTs	0.30	11	16	9.1	na	0.049	na	na
VOCs								
1,1-Dichloroethane	na	0.68	0.68	na	na	na	na	na
1,2,4-Trimethylbenzene	na	5.3	13	na	na	7.2	na	na
1,3,5-Trimethylbenzene	na	1.3	3.0	na	na	3	na	na
Benzene	na	0.33	0.51	0.0077	na	39	3.1	na
Chlorobenzene	na	0.22	na	na	na	80	na	na
cis-1,2-Dichloroethene	na	8.7	130	na	na	na	na	na
Dichloromethane	na	0.020	0.047	na	na	na	na	na
Ethylbenzene	na	1.9	3.1	na	na	na	na	na
n-Propylbenzene	na	na	na	na	na	11	na	na
tert-Butyl methyl ether	na	na	na	na	na	28	na	na
trans-1,2-Dichloroethene	na	5.5	5.5	na	na	na	na	na
Trichloroethene	na	0.16	0.27	0.0075	na	na	na	na
Vinyl chloride	na	1.2	1.2	na	na	0.5	0.5	na
Total xylenes	na	10	16	na	na	na	na	na
TPH								
TPH-gasoline (aliphatic) ^c	na	430	660	25	34	na	na	na
TPH-diesel (aliphatic) ^c	na	na	na	780	na	na	na	na

^a Facility soil EPCs are different for the worker scenarios because different exposure areas were assumed for these datasets (see Section 3.1).

^b Lead is included in this table because it was designated as a COPC. However, risks associated with lead were evaluated separately, as discussed in Section B.3.3.6, using the IEUBK and the ALM for characterizing risks associated with adult lead exposure. As discussed in Section 3.3.6, mean concentrations, rather than UCL values, were used for lead modeling.

^c As discussed in Section 2.2.5, aliphatic TPH fractions were assumed to be equal to 85% of each TPH fraction based on ATSDR (1999).

ALM – Adult Lead Model	EPC – exposure point concentration	PCB – polychlorinated biphenyl
COPC – contaminant of potential concern	IEUBK – Integrated Exposure Uptake Biokinetic Model for	SVOC – semivolatile organic compound
cPAH – carcinogenic polycyclic aromatic hydrocarbon	Lead in Children	TEQ – toxic equivalent
DDT – dichlorodiphenyltrichloroethane	na – not applicable (not a COPC for that scenario-media	TPH – total petroleum hydrocarbons
dw – dry weight	combination)	VOC – volatile organic compound
EPA – US Environmental Protection Agency	PAH – polycyclic aromatic hydrocarbon	ww – wet weight

3.3.6 Evaluation of Exposures to Lead

Risk estimates from lead exposure were not made using the equations presented in Section 3.3.1 because of the unique toxicology of lead. As discussed in EPA guidance on lead risk assessment (EPA 2011), lead is evaluated based on a blood lead level for the following reasons:

- **Lack of an RfD:** RfDs, as discussed in Section 4.0, are developed based on concentrations below which no adverse health effects have been observed. For lead, no RfD is available because exposure to even very low concentrations of lead has been observed to result in adverse health effects.
- **Toxicokinetics:** The toxicokinetics of lead (i.e., the rate at which lead enters the body and its fate once it is in the body) are well understood, which makes it possible to correlate blood lead levels with exposure. EPA and the Centers for Disease Control and Prevention (CDC) have determined that adverse health effects are associated with a blood lead level of 10 µg/dL or higher in children.

Two models were used in this HHRA: the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994) and the Adult Lead Model (ALM) (EPA 2003b), for which the sensitive endpoint is a fetus. The details of each model are discussed in the following subsections.

3.3.6.1 Children (IEUBK)

The IEUBK model (Version 1.1 build 9 for Microsoft Windows®) predicts blood-lead concentrations for children exposed to lead in their environment. The model requires relevant absorption parameters and intake and exposure rates and then estimates the concentration of lead in blood of children aged 0 to 6 years.

Default input parameters in the model for lead intake via air, drinking water, and diet were available for the evaluation of child exposure to lead at the Study Area. The IEUBK model also allows for alternate dietary data to be used if site-specific data are available. If site-specific data are available, they are used as input on both the concentration of lead in the alternate dietary sources as well as the proportion of total dietary intake these categories represent. The alternate dietary data are then added to the other source data to derive a combined intake from all sources.

For this HHRA, all default parameters recommended for use in the model by EPA were maintained except for alternate dietary source (fish) and soil lead concentrations (data for other food-borne sources of lead were not available). The default values for diet varied from 1.95 to 2.26 µg/day. Table 3-24 presents the alternate food source lead concentration (in fish) as well as the proportion of dietary intake represented by fish.

Table 3-24. Input parameters for IEUBK lead model

Parameter	Value	Unit
Mean lead concentration	60 (wetland soil) 40 (Force Lake sediment)	mg/kg dw
Time-weighted average lead concentrations based on sediment and soil exposures ^a	192 (wetland soil) 190 (Force Lake sediment)	mg/kg dw
Ingestion rate	1.05 (children aged 0 to 6)	g/day
Alternate food source concentration	2.0	µg lead/g
Alternate food source fraction ^b	1.07 (children aged 0 to 6)	%

^a Derived from lead values: $[(Pb_s \times EF_s) + (Pb_{default} \times EF_{default}) / (EF_s + EF_{default})]$

Where:

Pb_s = mean sediment or soil lead concentration (mg/kg dw)
 EF_s = Force Lake recreational user exposure frequency (22 days/year)
 $Pb_{default}$ = average default soil lead concentration (200 mg/kg dw)
 $EF_{default}$ = soil exposure frequency; calculated by subtracting the Study Area exposure frequency from the total number of days in the year, $EF_s + EF_{default} = 365$ (value is 343 days/yr)

^b 1.05 g/day (child aged 0 to 6 fish ingestion rate)/98.05 g/day (total meat consumed per day) (EPA 2006b).

dw – dry weight

EPC – exposure point concentration

Alternate dietary data from the child portion of the Force Lake fish consumer RME scenario were included in the model as described in Table 3-24. The IEUBK model applies average or CT estimates for all terms (EPA 1994). The fish consumption rate of 1.05 g/day for children aged 0 to 6 was used for this evaluation. The percentage of this alternate food source (fish) of its food group (all meat) was set at 1.07% (Table 3-24). Table 3-24 presents the input parameter used in the lead fish consumption model.

Exposure to lead in soil or sediment was calculated as a time-weighted average in accordance with direct sediment exposure scenarios for children. On days when a child visited the Study Area, all of their lead exposure was assumed to come from the Study Area; on days when the Study Area was not visited, the default value of 200 µg/g was used. Using a weighted average allowed for a better estimate of true soil exposure. However, it should be noted that the pre-set value of 200 µg/g was higher than all lead concentrations detected in Force Lake sediment and higher than all but four of the lead concentrations detected in wetland soil. This default value represents the concentration of lead immediately outside the home (as compared to the Study Area).

For calculating the time-weighted average EPC, an exposure frequency of 22 days per year was assumed for exposure to both soil and sediment at the Study Area (calculated separately). On days when exposure to sediment or soil at the Study Area did not occur (i.e., 343 days per year), children were assumed to be exposed to soils at the default lead concentration of 200 mg/kg dw. The time-weighted average EPC was

calculated for each exposure area by multiplying the sediment or soil concentration by the number of days exposed to either the default lead concentration or to the Study Area lead concentration. These values were summed, and the results were divided by an averaging time of 365 days per year. The results of these calculations are presented in Table 3-24.

The values calculated using default values recommended by EPA in the IEUBK model manual along with these site-specific data may not fully reflect the extent of lead exposure to children living in areas surrounding the Study Area because of the lack of site-specific data for lead in household dust, water, and residential soils in the neighborhoods surrounding the Study Area. These values included an assumed 200 mg/kg dw default soil lead concentration, which was intended to reflect an anthropogenic geometric mean concentration in urban areas. A regional soil background value of 17 mg/kg dw for lead is available from DEQ (2002), but because of the uncertainty associated with lead concentrations in urban areas, the more conservative (i.e., health-protective) default value from the IEUBK model was used.

It should be noted that even the highest time-weighted average lead EPCs presented in Table 3-23 based on Study Area sediment or soil exposure is less than the IEUBK model default value of 200 mg/kg dw. The results of the IEUBK model runs are presented in Section 5.4.1.

3.3.6.2 Adult (ALM)

The ALM is based on protecting the developing fetus of a pregnant woman. The model incorporates exposure to soil that is more representative of older children and adults than young children. Accordingly, EPA has used this model to estimate soil lead cleanup levels for sites at which the likely exposed population would be older children or adults. Although the model was developed to assess soil exposures, it has been applied to the Study Area to evaluate exposure to lead in wetland soil, lake sediment, and fish tissue consumption. Adjustments were made to the model to account for fish intake (EPA 2007a). This approach provides a way to evaluate cumulative exposure to lead at the Study Area from both sediment contact and fish consumption.

The ALM applied for the Study Area estimates an average blood lead level in adults based on additional exposure (above a baseline level) from lead in soil, sediment, fish, and air. An estimated fetal blood lead level is then calculated from the estimated adult blood lead levels (Equation 3-10). The contribution of lead from air at the Study Area was considered negligible because blood lead levels are much less sensitive to passive re-entrainment of lead from soil in air. The equation is thus:

$$PbB_{adult,central} = \frac{PbB_0 + BKSf \times FI \times ((PB_s \times IR_s \times AF_s \times EF_s) + (PB_f \times IR_f \times AF_f \times EF_f))}{AT}$$

Equation 3-10

where $PbB_{adult,central}$ is the geometric mean blood lead level (µg/dL) in exposed adults. The definition and parameterization of the other variables in the equation above are provided in Table 3-25. A summary of the

dataset to determine mean EPC values is presented in Table 3-26. This information replicates what is presented in EPC Tables 3-22 and 3-23, but is presented again here for the convenience of the reader. The same dataset was used to determine these mean EPCs as was used for the calculation of EPCs for other COPCs.

Table 3-25. Input Parameters for ALM

Parameter	Description	Value	Unit
General			
PbB ₀	adult baseline (geometric mean) blood lead level	1.5	µg/dL
BKSF	biokinetic slope factor	0.4 (EPA default)	µg/dL per µg/day
FI	fractional intake	1	unitless
AF _s	GI absorbance fraction for lead in sediment	0.12 (EPA default for soil) ^a	unitless
AF _t	GI absorbance fraction for lead in tissue	0.12 ^b	unitless
AT	averaging time	365	days
Industrial (Construction/Trenching) Worker			
IR _s	soil incidental ingestion rate	0.33	g/day
EF	exposure frequency	250	days/year
Pb _s	lead concentration in soil	40	mg/kg dw
Pb _w	lead concentration in groundwater	2	µg/L
Future Outdoor Worker			
IR _s	soil incidental ingestion rate	0.1	g/day
EF	exposure frequency	250	days/year
Pb _s	lead concentration in soil	60	mg/kg dw
Force Lake Recreational User			
IR _s	soil or sediment incidental ingestion rate	0.1	g/day
EF	exposure frequency	22	days/year
Pb _s	lead concentration in wetland soil	60	mg/kg dw
Pb _w	lead concentration in Force Lake sediment	40	mg/kg dw
Force Lake Fish Consumer			
IR _f	fish consumption rate	3.75	g/day
EF	exposure frequency	365	days/year
Pb _f	lead concentration in fish tissue (calculated)	1.4	mg/kg ww

^a Gastrointestinal absorption fraction for lead in sediment (EPA 2003b).

^b Gastrointestinal absorption fraction for lead in tissue (EPA 2007a).

ALM – Adult Lead Model

dw – dry weight

EPA – US Environmental Protection Agency

GI – gastrointestinal

ww – wet weight

Table 3-26. Summary of Lead Data and Mean EPC Values

Exposure Scenario	Media	Detection Frequency	Concentration (mg/kg dw)			
			Mean EPC	Max Detect	Max RL	UCL EPC
Industrial (construction/trenching worker)	Facility soil	112/112	40	337	na	71
	groundwater	8/28	2	19.6	1 U	3.0
Future outdoor worker	Facility soil	69/69	60	337	na	77
Force Lake recreational user	wetland soil	61/61	60	320	na	80
	Force Lake sediment	11/11	40	56	na	62
Force Lake fish consumer	calculated fish tissue ^a	11/11	2.0	2.8	na	3.1

^a Fish tissue concentrations were calculated using BSAFs (see Attachment 2).

BSAF – biota-sediment accumulation factor

RL – reporting limit

dw – dry weight

UCL – upper confidence limit on the mean

EPC – exposure point concentration

U – not detected at given concentration

na – not applicable

Lead EPC values were calculated for all exposure media based on the UCL as was done for all other COPCs evaluated in the HHRA. However, because the ALM guidelines (EPA 2003b) recommend using mean sediment and tissue values for calculating risks from lead exposure, mean values were calculated and applied in the ALM. Table 3-26 presents the mean concentrations as well as the EPC values based on the 95th UCL for all scenario-media combinations in which lead was identified as a COPC. The model output includes both central tendency (geometric mean) and 95th percentile fetal blood lead levels. The 95th percentile fetal blood lead level was calculated using Equation 3-11:

$$PbB_{fetal95} = PbB_{adult,central} \times GSD_{i,adult}^{1.645} \times R_{fetal/maternal} \quad \text{Equation 3-11}$$

Where:

$PbB_{fetal95}$ = 95th percentile fetal blood lead level (µg/dL)

$PbB_{adult,central}$ = central estimate of maternal adult blood lead concentration

$GSD_{i,adult}$ = geometric standard deviation of the blood lead distribution

1.645 = 95th percentile value for the Student's t distribution

$R_{fetal/maternal}$ = proportionality constant between fetal and maternal blood lead concentration

The geometric standard deviation (GSD) is an estimation of variation in blood lead levels around the geometric mean. It is used to estimate upper percentile blood lead levels for an individual and provides a health-protective estimate of the probability of an individual exceeding a given blood lead level (target risk goal). In accordance with EPA (2002a), a

GSD of 2.11 was applied to this model. Fetal blood lead levels were predicted based on the EPA assumption that fetal blood lead levels at birth are 90% of the maternal blood lead level. A 10 µg/dL blood lead level for a fetus is associated with a 11.1 µg/dL blood lead level for the mother according to EPA (2003b). The probability of exceeding the 10-µg/dL blood lead threshold for an individual was calculated using the following mathematical function in Microsoft Excel® using Equation 3-12:

$$P_{\text{exceedance}} = 1 - \text{Normdist}(\ln(\text{Pb}_{\text{target}}/\text{Pb}_{\text{central}} \times R_{\text{fetal/maternal}}) / \ln(\text{GSD}))$$

Equation 3-12

Where:

$\text{Pb}_{\text{target}}$	=	child threshold blood lead level (in this application, 10 µg/dL)
$\text{Pb}_{\text{central}}$	=	child central tendency blood lead estimate
$R_{\text{fetal/maternal}}$	=	proportionality constant between fetal and maternal blood lead concentration
GSD	=	geometric standard deviation of the blood lead distribution

3.4 Chronic Daily Intake

The CDI is defined in RAGS as “exposure expressed as mass of a substance contacted per unit body weight per time unit averaged over a long period of time” and is thus presented in units of milligrams per kilogram of body weight per day (mg/kg-day) (EPA 1989). The CDI is calculated differently for carcinogenic effects than for non-carcinogenic effects. Each is described below:

- **Carcinogens:** The CDI is based on the estimated exposure duration, extrapolated over an estimated 70-year lifetime. This is consistent with the cancer slope factors (SFs), which are based on lifetime exposures, and on the assumptions that the risk of carcinogenic effects is cumulative and continues even after exposure has ceased.
- **Non-carcinogens:** The CDI is averaged over the estimated exposure period to be consistent with the assumption that adverse effects are not expected to occur after exposure has ceased. Thus, the CDI is used to represent the potential for adverse health effects over the period of exposure.

Tables 1 through 6 in Attachment 5 present the results of CDI calculations performed using Equations 3-1 through 3-9 and the exposure parameters provided in Tables 3-8 through 3-19. The CDI results are used in the risk characterization (Section 5.0).

4.0 TOXICITY ASSESSMENT

A toxicity assessment includes two steps:

- Hazard identification, which determines whether exposure to a chemical may result in a deleterious health effect in humans. It consists of a characterization of the nature of the effect and the strength of the evidence that the chemical will cause the observed effect.
- Dose-response assessment, which includes a characterization of the relationship between the dose and the incidence and/or severity of the adverse health effect in the exposed population.

For risk assessment purposes, chemicals are generally categorized based on whether they exhibit carcinogenic or non-carcinogenic health effects. Because chemicals that are suspected carcinogens may also have non-carcinogenic effects, they must be evaluated separately for both effects. The toxicity assessment is an evaluation of each COPC's potential to cause health effects based on available toxicological information.

Quantitative estimates of toxicity have been developed by EPA and other agencies; this section presents a summary of the toxicity values for each COPC. Additional information regarding the toxicity, pharmacokinetics, acute toxicity, chronic toxicity, and potential carcinogenicity of each COPC is presented in Attachment 6. According to a hierarchy provided by EPA (2003a, 2009j), the following sources were used to estimate risks to humans in the baseline HHRA:

- **Tier 1:** EPA's Integrated Risk Information System (IRIS) database
- **Tier 2:** EPA's Provisional Peer-Reviewed Toxicity Values (PPRTVs) (developed as requested by EPA's Superfund program by the Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center)
- **Tier 3:** Other toxicity values, including additional EPA and non-EPA sources. Sources included California EPA (Cal EPA), the Agency for Toxic Substances and Disease Registry (ATSDR), and EPA's 1997 Health Effects Assessment Summary Tables (HEAST) document. Toxicity values were selected from current sources that were publicly available, were peer-reviewed, and were transparent in the presentation of methods used.

For each COPC, both cancer and non-cancer risks were quantitatively evaluated when toxicity information was available. Cancer risks were estimated using an oral cancer SF or an inhalation unit risk factor; non-cancer risks were estimated using an oral RfD or an inhalation reference concentration (RfC). For each COPC, a search was conducted to identify

both cancer and non-cancer toxicity values. If no toxicity information was available, a similar chemical was used as a surrogate when an appropriate surrogate existed (e.g., ethylbenzene was used as a surrogate for n-propylbenzene).

The RfD and RfC are estimates of the daily exposure of the human population, including sensitive sub-populations, that is not predicted to result in deleterious effects during a lifetime. These toxicity values are presented in Tables 4-1 and 4-2. In developing toxicity values for non-carcinogenic effects, EPA reviews available data to identify the most sensitive endpoint and population (i.e., the effects that occur at the lowest concentration). These available data include effects on children and other sensitive sub-populations. COPCs may have additional adverse effects that occur at higher exposure levels. The uncertainty in the RfD and RfC estimates is perhaps an order of magnitude or greater (EPA 2010b), as shown by the uncertainty factors in Tables 4-1 and 4-2, which were used by EPA when deriving RfDs and RfCs to ensure that these values would be sufficiently conservative (i.e., health-protective).

Table 4-1. Non-Cancer Toxicity Data (Oral/Dermal) for COPCs

COPC ^a	Class	Oral RfD (mg/kg-day)	Critical Effect	UF	Source	Source Date ^b	Notes
Aluminum	metals	1	neurological effects	100	PPRTV	April 2009	
Antimony	metals	0.0004	longevity, blood glucose, and cholesterol	1,000	IRIS	7/20/2009	
Arsenic	metals	0.0003	hyperpigmentation, keratosis and possible vascular complications	3	IRIS	7/20/2009	based on inorganic arsenic
Barium	metals	0.2	nephropathy	300	IRIS	7/23/2009	
Cadmium	metals	0.001	significant proteinuria	10	IRIS	7/23/2009	selected RfD is applicable to exposure via food ingestion
Chromium	metals	1.5	none reported	100	IRIS	9/15/2011	based on chromium (III) ^c
Cobalt	metals	0.0003	decreased iodide uptake	300	PPRTV	April 2009	
Copper	metals	0.04	na	na	HEAST	April 2009	
Iron	metals	0.7	na	na	PPRTV	April 2009	
Manganese	metals	0.14	central nervous system effects (other effects include impairment of neurobehavioral function)	1	IRIS	7/20/2009	
Mercury	metals	0.0001	developmental neuropsychological impairment	10	IRIS	7/23/2009	based on methylmercury ^d
Nickel	metals	0.02	decreased body and organ weights	300	IRIS	7/23/2009	
Vanadium	metals	0.005	decreased hair cystine	na	EPA RSL user's guide	April 2009	RfD for vanadium and compounds; adapted from the RfD for vanadium pentoxide ^e
Zinc	metals	0.3	decrease in erythrocyte copper, zinc-superoxide dismutase activity in healthy adults	3	IRIS	7/23/09	
Naphthalene	PAHs	0.02	decreased mean terminal body weight in males	3,000	IRIS	7/21/2009	
1,4-Dichlorobenzene	other SVOCs	0.07	na	na	ATSDR	April 2009	

Table 4-1. Non-Cancer Toxicity Data (Oral/Dermal) for COPCs

COPC ^a	Class	Oral RfD (mg/kg-day)	Critical Effect	UF	Source	Source Date ^b	Notes
Total PCBs	PCBs	0.00002	ocular xudates, inflamed and prominent Meibomian glands, distorted growth; decreased antibody response	300	IRIS	7/20/2009	based on Aroclor 1254, the lowest and most protective RfD available for PCBs in IRIS
Total DDTs	pesticides	0.0005	liver lesions	100	IRIS	7/21/2009	
1,1-Dichloroethane	VOCs	0.2	increased urinary enzyme markers	3,000	PPRTV	April 2009	
1,2,4-Trimethylbenzene	VOCs	0.05	na	na	PPRTV	April 2009	provisional value
1,3,5-Trimethylbenzene	VOCs	0.05	na	na	PPRTV	April 2009	
Benzene	VOCs	0.004	decreased lymphocyte count	300	IRIS	7/20/2009	
Chlorobenzene	VOCs	0.02	histopathologic changes in liver	1,000	IRIS	7/20/2009	
cis-1,2-Dichloroethene	VOCs	0.01	na	na	PPRTV	April 2009	
Dichloromethane	VOCs	0.06	liver toxicity	100	IRIS	7/20/2009	
Ethylbenzene	VOCs	0.1	liver and kidney toxicity	1,000	IRIS	7/20/2009	
n-Propylbenzene	VOCs	0.1	liver and kidney toxicity	1,000	IRIS	7/20/2009	surrogate = ethylbenzene
Total xylenes	VOCs	0.2	decreased body weight, increased mortality	1,000	IRIS	7/20/2009	
trans-1,2-Dichloroethene	VOCs	0.02	na	na	IRIS	April 2009	
Vinyl chloride	VOCs	0.003	liver cell polymorphism	30	IRIS	7/20/2009	
TPH-gasoline (aliphatic)	TPH	0.3	reduced nerve connection velocity	na	PPRTV	Sept. 2009	EPA (2009f)
TPH-diesel (aliphatic)	TPH	0.01	liver, kidney, and hematologic effects	na	PPRTV	Sept. 2009	EPA (2009f)

^a COPCs for which no RfD was available were excluded from this table. These COPCs include cPAH TEQ, tert-butyl methyl ether, and trichloroethene.

^b The IRIS date is the date that the database was searched; the ATSDR, HEAST, EPA RSL table and PPRTV dates are the dates that the RSL tables or PPRTV reference documents (the sources of the ATSDR, HEAST, and PPRTV values) were updated.

^c The toxicity value for trivalent chromium (chromium III), as opposed to hexavalent chromium (chromium VI), was used in this HHRA because there is no evidence to suggest that hexavalent chromium is present at the Study Area. Trivalent chromium occurs naturally in the environment and is an essential nutrient, while hexavalent chromium is produced as a result of industrial processes.

^d Mercury is a COPC only for the Force Lake fish consumer scenario. The toxicity value for methylmercury was selected for use in this HHRA because the majority of mercury present in fish tissue is methylmercury (EPA 2000a).

^e The RfD for vanadium and compounds was used in this HHRA. This RfD was adapted by EPA for use in the RSL tables by adjusting the vanadium pentoxide RfD (0.009 mg/kg-day) by the difference in molecular weight. The molecular weight of vanadium is 56% of the molecular weight of vanadium pentoxide, and thus the RfD was scaled based on this factor (0.009 multiplied by 56%).

ATSDR – Agency for Toxic Substances and Disease Registry	na – not applicable or available	SVOC – semivolatile organic compound
COPC – contaminant of potential concern	PAH – polycyclic aromatic hydrocarbon	TEQ – toxic equivalent
cPAH – carcinogenic polycyclic aromatic hydrocarbon	PCB – polychlorinated biphenyl	TPH – total petroleum hydrocarbons
DDT – dichlorodiphenyltrichloroethane	PPRTV – Provisional Peer-Reviewed Toxicity Values	UF – uncertainty factor
HEAST – Health Effects Assessment Summary Tables	RfD – reference dose	VOC – volatile organic compound
IRIS – Integrated Risk Information System	RSL – regional screening level	

Table 4-2. Non-Cancer Toxicity Data (Inhalation) for COPCs

COPC ^a	Class	Inhalation RfC (mg/m ³)	Critical Effect	UF	Source	Source Date ^b	Notes
Arsenic	metals	0.000015	na	na	Cal EPA	April 2009	based on inorganic arsenic
Cobalt	metals	0.000006	respiratory tract irritation and decreased lung function	300	PPRTV	April 2009	
Manganese	metals	0.00005	impairment of neurobehavioral function	1,000	IRIS	7/20/2009	
Naphthalene	PAHs	0.003	nasal effects including hyperplasia and metaplasia in respiratory and olfactory epithelium	3,000	IRIS	7/21/2009	
1,4-Dichlorobenzene	other SVOCs	0.8	increased liver weights	100	IRIS	7/20/2009	
1,1-Dichloroethane	VOCs	0.5	kidney damage	1,000	RAIS	7/20/2009	
1,2,4-Trimethylbenzene	VOCs	0.007	decreased blood clotting time	3,000	IRIS	April 2009	
1,3,5-Trimethylbenzene	VOCs	0.006	na	na	PPRTV	April 2009	
Benzene	VOCs	0.03	decreased lymphocyte count	300	IRIS	7/20/2009	
Chlorobenzene	VOCs	0.05	na	na	PPRTV	April 2009	
Ethylbenzene	VOCs	1	developmental toxicity	300	IRIS	7/20/2009	
n-Propylbenzene	VOCs	1	developmental toxicity	300	IRIS	7/20/2009	surrogate = ethylbenzene
tert-Butyl methyl ether	VOCs	3	increased liver and kidney weights; increased severity of spontaneous renal lesions (females), and swollen periocular tissue (males and females)	100	IRIS	7/20/2009	
trans-1,2-Dichloroethene	VOCs	0.06	pulmonary capillary hyperemia, distention of the alveolar septum, and fatty degeneration of the liver	3,000	PPRTV	April 2009	
Vinyl chloride	VOCs	0.1	liver cell polymorphism	30	IRIS	7/20/2009	
Total xylenes	VOCs	0.1	impaired motor coordination (decreased rotarod performance)	300	IRIS	7/20/2009	
TPH-gasoline (aliphatic)	TPH	0.6	nasal epithelial cell hyperplasia	na	PPRTV	Sept. 2009	EPA (2009f)

^a COPCs for which no RfC was available were excluded from this table. These COPCs include copper, cPAH TEQ, total PCBs, total DDTs, cis-1,2-dichloroethene, dichloromethane, and trichloroethene.

^b The IRIS date is the date that the database was searched; the HEAST and PPRTV dates are the dates that the RSL tables or PPRTV reference documents (the sources of the HEAST and PPRTV values) were updated.

COPC – contaminant of potential concern

Cal EPA – California Environmental Protection Agency

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

HEAST – Health Effects Assessment Summary Tables

IRIS – Integrated Risk Information System

na – not applicable or available

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PPRTV – Provisional Peer-Reviewed Toxicity Values

RAIS – Risk Assessment Information System

RfC – reference concentration

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

UF – uncertainty factor

VOC – volatile organic compound

The SF and inhalation unit risk factor represent plausible upper-bound estimates of the probability of a carcinogenic response per unit intake of a COPC over a lifetime. EPA has recently updated the guidance for carcinogen risk assessment to emphasize consideration of the mode of action (e.g., mutagenesis) in the development of SFs (EPA 2005a). In general, the SF is based on a dose-response curve using available carcinogenic data for a given COPC. Mathematical models are used to extrapolate from high experimental doses to the low doses expected for human contact in the environment. The selection of the mathematical model for dose extrapolation (e.g., linear or nonlinear) is generally informed by the mode of action of the COPC (EPA 2005a).

As previously noted in Section 2.2.4, the cPAH TEQ is composed of individual compounds that have similar structures as well as a common mechanism of toxicity. Thus, the toxicity assessment is based on the group, rather than on an individual compound. The specific PAHs included in the cPAH group were presented in Table 2-5. The toxicity of multiple cPAHs is generally evaluated using the relative potency approach. This approach involves a comparison of the cancer-causing ability of a particular cPAH with a reference compound, benzo[a]pyrene (BaP), by means of a potency equivalency factor. A cPAH with a factor of 1.0 is assumed to have the same cancer-inducing potency as BaP. A cPAH with a factor of 0.5 would be assumed to have half the cancer-inducing potency of BaP, and so forth. Potency equivalency factors for cPAHs have been developed by Cal EPA (California EPA 1994) based on various toxicity endpoints and were presented in Table 2-5.

The cancer toxicity values used in this HHRA are summarized in Tables 4-3 and 4-4. In addition to toxicity values, Tables 4-3 and 4-4 present cancer weight-of-evidence descriptors, which are used to describe a chemical's cancer-causing potential in humans. EPA's 1986 guidelines (EPA 1986) used groups A through E to describe cancer-causing potential (i.e., group A for known human carcinogens through group E for evidence of non-carcinogenicity in humans). Under EPA's updated 2005 guidelines for carcinogen risk assessment, a narrative approach, rather than the 1986 alphanumeric categories, is used to characterize carcinogenicity. The five standard weight-of-evidence descriptors developed as part of the 2005 guidance are as follows: carcinogenic to humans, likely to be carcinogenic to humans, suggestive evidence of carcinogenic potential, inadequate information to assess carcinogenic potential, and not likely to be carcinogenic to humans. For COPCs for which no EPA descriptors are available, International Agency for Research on Cancer (IARC) carcinogen classifications were used when available.

Table 4-3. Cancer Toxicity Data (Oral/Dermal) for COPCs

COPC ^a	Class	Cancer Weight-of-Evidence Descriptor ^b	Oral Cancer Slope Factor (mg/kg-day) ⁻¹	Source	Source Date ^c	Notes
Arsenic	metals	A	1.5	IRIS	7/20/2009	based on inorganic arsenic
Cobalt	metals	likely to be carcinogenic to humans	na	PPRTV	na	
Mercury	metals	C	na	IRIS	na	based on methylmercury ^d
Naphthalene	PAHs	C	na	IRIS	na	
cPAH TEQ	PAHs	B2	7.3	IRIS	7/20/2009	based on benzo(a)pyrene ^e
1,4-Dichlorobenzene	other SVOCs	2B (IARC)	0.0054	Cal EPA	April 2009	
Total PCBs	PCBs	B2	2	IRIS	7/20/2009	upper-bound slope factor used for this risk estimate
Total DDTs	pesticides	B2	0.34	IRIS	7/21/2009	
1,1-Dichloroethane	VOCs	C	0.0057	Cal EPA	April 2009	
Benzene	VOCs	A	0.055	IRIS	7/20/2009	
Dichloromethane	VOCs	B2	0.0075	IRIS	7/20/2009	
tert-Butyl methyl ether	VOCs	na	0.0018	Cal EPA	April 2009	
Trichloroethene	VOCs	2A (IARC)	0.13 ^f	Cal EPA	April 2009	
Vinyl chloride (non-occupational exposure)	VOCs	A	1.5	IRIS	7/20/2009	based on continuous lifetime exposure from birth
Vinyl chloride (occupational exposure)	VOCs	A	0.72	IRIS	7/20/2009	based on continuous lifetime exposure during adulthood

^a COPCs included in this table are either known, probable, or possible human carcinogens(see below). Cadmium and TPH, although considered to be potential carcinogens, are excluded from this table because they are carcinogens only via the inhalation pathway (see Table 4-4). In addition, n-propylbenzene was not evaluated for the carcinogenic oral or dermal pathways per EPA guidance (EPA 2009g).

^b EPA's cancer weight-of-evidence descriptors (as presented in IRIS) were the primary classification used to describe carcinogenic potential. When available, the 2005 narrative descriptors were used; otherwise the 1986 alphanumeric descriptors were used. In addition, IARC classifications were used when no EPA descriptors were available. The 1986 alphanumeric EPA descriptors and IARC group classifications used in this table are as follows: A = known human carcinogen; B1 = probable human carcinogen (based on limited evidence of carcinogenicity in humans); B2 = probable human carcinogen (sufficient evidence in animals and inadequate or no evidence in humans); C = possible human carcinogen (limited evidence from animal studies and inadequate or no data in humans); D = not

classifiable as to human carcinogenicity; 2A = probably carcinogenic to humans; 2B = possibly carcinogenic to humans. The 2005 descriptors are narrative, and thus abbreviations are not used.

- ^c The IRIS date is the date that the database was searched; the Cal EPA dates are the dates that the RSL tables (the sources of the Cal EPA values) were updated.
- ^d Mercury is a COPC only for the Force Lake fish consumer scenario. The toxicity value for methylmercury was selected for use in this HHRA because the majority of mercury present in fish tissue is methylmercury (EPA 2000a).
- ^e The cPAH TEQ sum was calculated based on potency equivalency factors, which relate the potency of the seven cPAHs in the Harbor Oil dataset to the most toxic of these PAHs (benzo(a)pyrene), as described in Section 2.2.4 and Cal EPA (1994). Thus, the benzo(a)pyrene toxicity value was used for cPAH TEQ.
- ^f The inhalation unit risk factor for trichloroethene was adjusted upward by a factor of 10, as recommended by EPA Region 10 (EPA 2010c).

COPC – contaminant of potential concern

Cal EPA – California Environmental Protection Agency

cPAH – carcinogenic PAH

DDT – dichlorodiphenyltrichloroethane

EPA – US Environmental Protection Agency

IARC – International Agency for Research on Cancer

IRIS – Integrated Risk Information System na – not applicable or available

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RAIS – Risk Assessment Information System

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

Table 4-4. Cancer Toxicity Data (Inhalation) for COPCs

COPC ^a	Class	Cancer Weight-of-Evidence Descriptor ^b	Inhalation Unit Risk Factor ($\mu\text{g}/\text{m}^3\text{-}1$)	Source	Source Date ^c	Notes
Arsenic	metals	A	0.0043	IRIS	7/20/2009	based on inorganic arsenic
Cobalt	metals	likely to be carcinogenic to humans	0.009	PPRTV	April 2009	
Naphthalene	PAHs	C	3.4×10^{-5}	Cal EPA	April 2009	
cPAH TEQ	PAHs	B2	0.001	Cal EPA	April 2009	inhalation unit risk factor based on benzo(a)pyrene ^d
1,4-Dichlorobenzene	other SVOCs	2B (IARC)	1×10^{-5}	Cal EPA	April 2009	
Total PCBs	PCBs	B2	0.0001	IRIS	7/20/2009	Low risk and persistence; upper-bound unit risk factor
Total DDTs	pesticides	B2	9.7×10^{-5}	IRIS	7/21/2009	
1,1-Dichloroethane	VOCs	C	1.6×10^{-6}	Cal EPA	April 2009	
Benzene	VOCs	A	7.8×10^{-6}	IRIS	7/20/2009	
Dichloromethane	VOCs	B2	4.7×10^{-7}	IRIS	7/20/2009	
tert-Butyl methyl ether	VOCs	na	3×10^{-7}	Cal EPA	April 2009	
Trichloroethene	VOCs	2A (IARC)	$2 \times 10^{-5\text{e}}$	Cal EPA	April 2009	
Vinyl chloride (non-occupational exposure)	VOCs	A	8.8×10^{-6}	IRIS	6/11/2010	based on continuous lifetime exposure from birth
Vinyl chloride (occupational exposure)	VOCs	A	4.4×10^{-6}	IRIS	6/11/2010	based on continuous lifetime exposure during adulthood
TPH-gasoline (aliphatic)	TPH	na	1.9×10^{-7}	PPRTV	Sept. 2009	EPA (2009f)

^a COPCs included in this table are either known, probable, or possible human carcinogens (see below). In addition, ethylbenzene and n-propylbenzene were not evaluated for the carcinogenic inhalation pathway per EPA guidance (EPA 2009g).

^b EPA's cancer weight-of-evidence descriptors (as presented in IRIS) were the primary classification used to describe carcinogenic potential. When available, the 2005 narrative descriptors were used; otherwise the 1986 alphanumeric descriptors were used. Additionally, IARC classifications were used when no EPA descriptors were available. The 1986 alphanumeric EPA descriptors and IARC group classifications used in this table are as follows: A = known human carcinogen; B1 = probable human carcinogen (based on limited evidence of carcinogenicity in humans); B2 = probable human carcinogen (sufficient evidence in animals and inadequate or no evidence in humans); C = possible human carcinogen (limited evidence from animal studies and inadequate or no data in humans); D = not classifiable as to human carcinogenicity; 2A = probably carcinogenic to humans; 2B = possibly carcinogenic to humans. The 2005 descriptors are narrative, and thus abbreviations are not used.

- ^c The IRIS date is the date that the database was searched, the Cal EPA dates are the dates that the RSL tables (the sources of the Cal EPA values) were updated, and the PPRTV date is the date that the document was updated.
- ^d The cPAH TEQ sum is calculated based on potency equivalency factors, which relate the potency of the seven cPAHs in the Harbor Oil dataset to the most toxic of these PAHs (benzo(a)pyrene), as described in Section 2.2.4 and Cal EPA (1994). Thus, the benzo(a)pyrene toxicity value was used for cPAH TEQ.
- ^e The inhalation unit risk factor for trichloroethene was adjusted upward by a factor of 10, as recommended by EPA Region 10 (EPA 2010c).

COPC – contaminant of potential concern

Cal EPA – California Environmental Protection Agency

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

EPA – US Environmental Protection Agency

IARC – International Agency for Research on Cancer

IRIS – Integrated Risk Information System

na – not applicable or available

PCB – polychlorinated biphenyl

PPRTV – Provisional Peer-Reviewed Toxicity Value

RAIS – Risk Assessment Information System

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

In addition, the non-cancer toxicological endpoints that were used to establish the RfDs and RfCs are summarized in Table 4-5. It should be noted that COPCs may have adverse effects other than the endpoints identified in Table 4-5 because these effects occur at higher doses than the doses represented by the RfD or RfC. For example, although not identified as a critical effect for the development of the RfD for PCBs (or PCB Aroclors) in IRIS (the critical endpoint for PCBs was the immune system), nervous system effects, particularly neurodevelopmental effects, are well documented across a range of PCB exposure levels (ATSDR 2000; Longnecker et al. 2003).

Table 4-5. Toxicological Endpoints by Exposure Pathway for COPCs with Non-Carcinogenic Effects

COPC	Body Weight	Cardiovascular System	Dermal	Development	Endocrine System	Eyes	Hematologic System	Immune System	Kidney	Liver	Nervous System	Nose	Reproductive System	Respiratory System
Metals														
Aluminum ^a											RfD			
Antimony ^a					O/D		O/D							
Arsenic ^b		O/D	O/D											
Barium ^a									O/D					
Cadmium ^a									O/D					
Chromium ^c														
Cobalt							O/D							I
Copper ^c														
Iron ^{a, c}														
Manganese											O/D, I			
Mercury ^a				O/D							O/D			
Nickel ^a	O/D				O/D				O/D	O/D				
Vanadium ^a			O/D											
Zinc ^a							O/D							
Other SVOCs														
1,4-Dichlorobenzene ^c										I				
PAHs														
Naphthalene	O/D											I		I
cPAH TEQ ^d														
PCBs														
Total PCBs				O/D				O/D						

Table 4-5. Toxicological Endpoints by Exposure Pathway for COPCs with Non-Carcinogenic Effects

COPC	Body Weight	Cardiovascular System	Dermal	Development	Endocrine System	Eyes	Hematologic System	Immune System	Kidney	Liver	Nervous System	Nose	Reproductive System	Respiratory System
Pesticides														
Total DDTs										O/D				
VOCs														
1,1-Dichloroethane									O/D, I					
1,4-Dichlorobenzene										I				
1,2,4-Trimethylbenzene ^c							I							
1,3,5-Trimethylbenzene ^{b,c}														
Benzene								O/D, I						
Chlorobenzene ^b										O/D,				
cis-1,2-Dichloroethene														
Dichloromethane										O/D				
Ethylbenzene				I					O/D	O/D				
n-Propylbenzene				I					O/D	O/D				
tert-Butyl methyl ether									I	I				
trans-1,2-Dichloroethene		I								I				I
Trichloroethene ^d														
Vinyl chloride										O/D, I				
Total xylenes	O/D										I			
Petroleum Hydrocarbons														
TPH-gasoline (aliphatic)											O/D	I		
TPH-diesel (aliphatic) ^a							O/D		O/D	O/D				

Note: Each of these COPCs will likely have additional toxic effect endpoints at exposures above the RfD or RfC. The toxicological profile section of the HHRA (Attachment 6) may be consulted by readers who desire more information on toxic effect endpoints.

- ^a Not a COPC for the industrial (construction/trenching scenario) and thus not evaluated based on the inhalation pathway. Therefore, no RfC effects are noted for these COPCs in this table.
- ^b No information was available regarding the RfC endpoint for this COPC.
- ^c No information was available regarding the RfD endpoint for this COPC.
- ^d No RfC or RfD was available for this COPC.
- ^e Nervous system effects for PCBs were not identified in IRIS for development of the RfD, but such effects, particularly neurodevelopmental effects, are well documented (ATSDR 2000).

ATSDR – Agency for Toxic Substances and Disease Registry

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

I – inhalation exposure; indicates the RfC for a particular COPC was based on the identified endpoint

O/D – oral and dermal exposure; indicates the RfD for a particular COPC was based on the identified endpoint

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

5.0 RISK CHARACTERIZATION

This section summarizes the approach for calculating risk estimates and presents the quantitative risk characterization results for the HHRA. In this step of the HHRA, risks were quantified by combining the results of the exposure assessment (Section 3) with the results of the toxicity assessment (Section 4).

These estimates characterize risks to people who could be exposed to COPCs present at the Study Area and identify contaminants of concern (COCs), which are defined here as COPCs with an excess cancer risk estimate greater than 1×10^{-6} or a non-cancer HQ greater than 1 for any RME scenario. For reference, the lifetime risk of developing cancer in the US population is one in two (i.e., 5×10^{-1}) for men and one in three (i.e., 3×10^{-1}) for women (American Cancer Society 2006). A 1×10^{-6} excess cancer risk represents an additional one-in-one-million probability that an individual may develop cancer through exposure to COPCs at the Study Area averaged over a 70-year lifetime.

Excess cancer risks greater than 1×10^{-6} do not necessarily indicate unacceptable risks; EPA's target risk range is between 1×10^{-6} and 1×10^{-4} . However, as a health-protective approach consistent with EPA guidance, risks greater than the lower end of this target risk range (i.e., above 1×10^{-6}) were identified in this HHRA.

This section also identifies COCs with the greatest contributions to the total risk estimates. In addition to the scenarios summarized in this section, a screening level assessment was done to assess risks based on residential exposure. The screening assessment for hypothetical future residents indicated that excess cancer risks would likely be greater than the upper end of EPA's target risk range (10^{-4}) and some chemicals would have an HQ greater than 1 based on the comparison of Study Area concentrations with regional screening levels (Attachment 1).

5.1 Risk Estimate Calculations

This section presents the equations that were used to calculate risks for the baseline HHRA. Carcinogenic and non-carcinogenic risks were evaluated separately. In addition, risks from exposure to lead were estimated using the IEUBK (EPA 1994, 2007b) and the ALM (EPA 2003b), rather than the equations presented in this section.

5.1.1 Carcinogenic Risks

Cancer risks are expressed as an excess lifetime cancer risk (i.e., the increased risk that an individual will develop cancer in his or her lifetime based on exposure to concentrations at the Study Area). Excess cancer risks are expressed as a probability in scientific notation (e.g., 1×10^{-6} ,

which is equivalent to 0.000001 or 1 in 1,000,000). Per EPA guidance (1989), only one significant figure is used when presenting excess cancer risks because of the uncertainty in cancer SFs and the parameters used to quantify risk. Equation 5-1 presents the method used to calculate carcinogenic risks for oral and dermal exposure, and Equation 5-2 presents the method used to calculate carcinogenic risks for inhalation exposure.

$$\text{Risk} = \text{CDI} \times \text{SF} \quad \text{Equation 5-1}$$

Where:

Risk	unitless	COPC-specific lifetime excess cancer risk
CDI	mg/kg-day	COPC-specific chronic daily intake rate
SF	(mg/kg-day) ⁻¹	route- and COPC-specific cancer slope factor

$$\text{Risk} = \text{EC} \times \text{IUR} \quad \text{Equation 5-2}$$

Where:

Risk	unitless	COPC-specific lifetime excess cancer risk
EC	μg/m ³	time-weighted COPC-specific inhalation exposure concentration
IUR	(μg/m ³) ⁻¹	COPC-specific inhalation unit risk

Cancer risks for individual COPCs are summed for each exposure pathway to determine the overall lifetime excess cancer risk associated with a given exposure scenario at the Study Area. For the recreational scenarios, which include exposure durations from birth to the age of 30, a calculation was performed to integrate risk estimates for three age groups (0 to 6, 7 to 16, and 17 to 30 years of age) to account for the different age-specific exposure parameters (e.g., body weight and surface area) for these age groups. Because excess cancer risk estimates are probabilities of an individual's increased cancer risk, the integrated lifetime risk estimate was calculated as the sum of risk estimates for the three age groups. Thus, the method used to calculate the cancer risk for the recreational scenarios is somewhat different than the method used to calculate excess cancer risk for the worker scenarios summarized in Sections 5.3.1, 5.3.2, and 5.3.3, which were all based on adult exposures only. For risks to children from COPCs with mutagenic modes of action,¹¹ EPA provides additional guidance because of the increased susceptibility of children and young adults to these contaminants (EPA 2005b). In this HHRA, cPAH TEQ is the only COPC that falls into this category. Risks to children from cPAH TEQ will be calculated as follows per EPA guidance: the slope factor will be multiplied by a factor of 10 for children aged 0 to 2, and by a factor of 3 for children aged 3 to 16. These factors account for the potentially higher susceptibility of young children to contaminants with mutagenic modes of action. Equation 5-3 presents the method used to calculate the excess cancer risk estimate for mutagens for oral and dermal exposure.

¹¹ A mutagen is a chemical that is capable of causing a mutation (i.e., a change in genetic structure).

$$\text{Risk} = (\text{CDI}_{\text{age0-2}} \times (\text{SF} \times 10)) + (\text{CDI}_{\text{age3-6}} \times (\text{SF} \times 3)) + (\text{CDI}_{\text{age7-16}} \times (\text{SF} \times 3)) + (\text{CDI}_{\text{age17-30}} \times \text{SF})$$

Equation 5-3

Where:

Risk	unitless	COPC-specific lifetime excess cancer risk
CDI	mg/kg-day	COPC-specific chronic daily intake rate based on the exposure duration for each age group (i.e., 6 years for age 0 to 6, 10 years for age 7 to 16, and 14 years for age 17 to 30)
SF	(mg/kg-day) ⁻¹	route- and COPC-specific cancer slope factor

It should be noted that a similar equation to calculate risks via inhalation exposure is not presented because the scenarios evaluated for child and/or lifetime risks (i.e., the Force Lake recreational and Force Lake fish consumer scenarios) do not include exposure via inhalation (as discussed in Section 3.1). Only the worker scenarios, which are evaluated only for adults, include risks based on inhalation exposure.

5.1.2 Non-Carcinogenic Risks

Non-cancer risks are expressed as an HQ, which is the ratio of the exposure dose to the COPC-specific RfD or RfC. Non-cancer risks are exceedance ratios, not probabilities. An HQ greater than 1 indicates that the exposure dose is greater than the toxicity threshold, and thus adverse effects may occur. Equation 5-4 presents the method used to calculate non-carcinogenic risks for oral and dermal exposure, and Equation 5-5 presents the method used to calculate non-carcinogenic risks for inhalation exposure.

$$\text{HQ} = \frac{\text{CDI}}{\text{RfD}}$$

Equation 5-4

Where:

HQ	unitless	hazard quotient
CDI	mg/kg-day	COPC-specific chronic daily intake rate
RfD	mg/kg-day	route- and COPC-specific reference dose

$$\text{HQ} = \frac{\text{EC}}{\text{RfC} \times \text{CF}}$$

Equation 5-5

Where:

HQ	unitless	hazard quotient
EC	µg/m ³	time-weighted COPC-specific inhalation exposure concentration
RfC	mg/m ³	COPC-specific reference concentration
CF	µg/mg	conversion factor (equal to 1,000)

Unlike excess cancer risks, HQs were not summed across age groups because non-cancer risks are not expressed as probabilities. The recreational scenarios include an exposure duration of 30 years, from birth to the age of 30. There are important behavioral, physiological, and

toxicological differences between children and adults that may cause children, particularly children under the age of 6, to be more exposed to some environmental contaminants (EPA 2008b). Thus, it is important to present the non-cancer risks to young children separately from older children and adults. Because HQs for the 0 to 6 age group were higher than HQs for older children and adults, decisions on the need for remediation are typically based on the HQs for the 0 to 6 age group. For risk communication purposes, however, it is useful to also present non-cancer HQs for the entire 30-year exposure duration, reflecting both childhood and adult exposure. Because the HQs across different age groups are not additive, an integrated HQ was calculated using the age group-specific HQs (i.e., 0 to 6, 7 to 16, and 17 to 30 years). Equation 5-6 presents the method for calculating the combined 0-to-30 year HQ, where the averaging time used in the CDI equations for each age group is based on the total exposure duration of 30 years (365 days × 30 years = 10,950 days).¹²

$$HQ = \left(\frac{CDI_{age0-6} + CDI_{age7-16} + CDI_{age17-30}}{RfD} \right) \quad \text{Equation 5-6}$$

Where:

HQ	unitless	weighted average hazard quotient for age classes ranging from 0 to 30 years
CDI	mg/kg-day	COPC-specific chronic daily intake rate based on the exposure duration for each age group (i.e., 6 years for age 0 to 6, 10 years for age 7 to 16, and 14 years for age 17 to 30) using the overall scenario averaging time of 30 years
RfD	mg/kg-day	COPC-specific reference dose

As noted above, the HQs for the entire 30-year exposure duration are presented for risk communication purposes only, and are not typically used for risk management decisions.

HQs for COPCs with similar toxicological effects (e.g., neurological damage) can be summed to calculate endpoint-specific hazard indices (HIs). If the overall HI was greater than 1 for a given scenario or exposure area, endpoint-specific HIs were calculated by summing the HQs for COPCs with common toxicological endpoints (e.g., all HQs calculated for the developmental endpoint).

5.2 Risk Characterization Format

Excess cancer risks and HQs are presented according to the format recommended in EPA (1998). The primary purpose of the HHRA is to characterize risks from COPCs at the Study Area in support of risk management decisions and remedial options. Risk estimates also provide

¹² Note that the CDIs calculated for each age group (i.e., 0 to 6, 7 to 16, and 17 to 30) in Equation 5-6 use the overall scenario averaging time of 30 years (10,950 days), which allows for the calculation of the average weighted HQ. These CDIs are different than those used to calculate non-cancer HQs for individual age groups or to calculate excess cancer risks, for which the averaging time for each age group is used.

information to the public about what their health risks may be from engaging in different activities associated with the Study Area (e.g., worker scenarios and Force Lake recreation scenarios).

Excess cancer risks are summed for all COPCs within each exposure scenario. Exposure scenarios in which the same receptor is exposed via multiple pathways simultaneously were addressed by summing the RME estimates for those pathways. This approach was applied to all direct sediment exposure scenarios that involved dermal absorption, incidental ingestion, and inhalation. In addition, excess cancer risk estimates were summed across media for scenarios assuming exposure to multiple media (e.g., facility soil and groundwater for the industrial [construction/trenching] worker RME scenario). For some combinations of exposure media, the highest risk estimate may be several orders of magnitude higher than those for the other media. The resulting risk estimate for the combination of multiple scenarios may then differ only slightly or not at all from the risk estimate for the RME scenario alone.

In this section, CDIs are presented with two significant figures; excess cancer risks and HQs are presented with only one significant figure. Sums of excess cancer risk estimates are reported with one significant figure as well. For example, the sum of excess risk estimates of 2×10^{-4} and 3×10^{-5} would be reported as 2×10^{-4} , not 2.3×10^{-4} . The overall HI and endpoint-specific HIs (sums of HQs for individual COPCs with similar toxicological endpoints) are presented with one significant figure if they are less than 1, or to the nearest integer if they are greater than 1. This is to allow the reader to follow summations. For example, HQs of 4 and 10 would be summed to equal 14, not 10. However, HQs of 0.01 and 0.001 would be summed to equal 0.01, not 0.011.

5.3 Risk Characterization Results

This section presents the results for each exposure scenario quantified in the baseline HHRA for the Study Area:

- **Industrial (construction/trenching) worker RME scenario:** Cancer and non-cancer risks for exposure to Facility soil and groundwater are presented in Section 5.3.1.
- **Future outdoor worker RME scenario:** Cancer and non-cancer risks for exposure to Facility soil are presented in Section 5.3.2.
- **Industrial/commercial worker vapor intrusion scenario:** Per EPA direction, risks were calculated using EPA screening levels (2002c). These screening levels for the COPCs identified as part of this scenario are based on carcinogenic risks, and thus non-cancer HQs were not calculated.
- **Force Lake recreational user RME scenario:** Cancer and non-cancer risks for exposure to wetland soil, lake sediment, and lake surface water are presented in Section 5.3.4.

- **Force Lake fish consumer RME scenario:** Cancer and non-cancer risks for exposure to fish tissue are presented in Section 5.3.5.

For those scenarios with excess cancer risk estimates greater than 1×10^{-6} or with endpoint-specific HIs greater than 1, risks estimates based on background or reference area¹³ concentrations are also discussed. In addition to these scenarios, Attachment 1 discusses the results of the screening assessment for hypothetical future residents.

5.3.1 Industrial (Construction/Trenching) Worker

This section presents cancer and non-cancer risks to workers through exposure to Facility soil and groundwater during construction or trenching activities (Tables 5-1 through 5-4). Excess cancer risks were greater than 1×10^{-6} for exposure to Facility soil, but not to groundwater. The total non-cancer HQ was less than 1 based on exposure to Facility soil or groundwater.

¹³ The term reference area is used instead of background for organic compounds because no specific background concentrations that are representative of anthropogenic background have been selected or approved by EPA. Instead, concentrations from reference areas (i.e., urban areas in the vicinity of the Study Area) are presented for comparison with Study Area concentrations.

Table 5-1. Excess Cancer Risk Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Facility Soil

Scenario timeframe: Current/future Medium: Facility soil Receptor population: Workers Receptor age: Adult										
COPC	EPC (mg/kg dw)	Cancer CDI (mg/kg-day)		Cancer EC ($\mu\text{g}/\text{m}^3$)	Cancer Slope Factor (mg/kg-day) ⁻¹	Inhalation Unit Risk Factor ($\mu\text{g}/\text{m}^3$) ⁻¹	Excess Cancer Risk			
		Incidental Ingestion	Dermal Absorption	Inhalation			Incidental Ingestion	Dermal Absorption	Inhalation	Total
Arsenic	8.3	3.8×10^{-7}	1.1×10^{-7}	5.1×10^{-9}	1.5	0.0043	6×10^{-7}	2×10^{-7}	2×10^{-11}	8×10^{-7}
Cobalt	13	6.0×10^{-7}	6.0×10^{-8}	8.0×10^{-9}	na	0.009	na ^a	na ^a	7×10^{-11}	7×10^{-11}
cPAH TEQ	0.95	4.4×10^{-8}	5.7×10^{-8}	5.9×10^{-10}	7.3	0.001	3×10^{-7}	4×10^{-7}	6×10^{-13}	7×10^{-7}
Naphthalene	2.0	9.2×10^{-8}	1.2×10^{-7}	6.1×10^{-7}	na	3.4×10^{-5}	na ^a	na ^a	2×10^{-11}	2×10^{-11}
Total PCBs	3.4	1.6×10^{-7}	2.2×10^{-7}	8.5×10^{-9}	2	0.0001	3×10^{-7}	4×10^{-7}	9×10^{-13}	7×10^{-7}
Total DDTs	11	5.1×10^{-7}	1.5×10^{-7}	6.8×10^{-9}	0.34	9.7×10^{-5}	2×10^{-7}	5×10^{-8}	7×10^{-13}	3×10^{-7}
1,1-Dichloroethane	0.68	3.1×10^{-8}	na ^b	1.4×10^{-4}	0.0057	1.6×10^{-6}	2×10^{-10}	na ^b	2×10^{-10}	4×10^{-10}
Benzene	0.33	1.5×10^{-8}	na ^b	4.9×10^{-5}	0.055	7.8×10^{-6}	8×10^{-10}	na ^b	4×10^{-10}	1×10^{-9}
Dichloromethane	0.02	9.2×10^{-10}	na ^b	4.2×10^{-6}	0.0075	4.7×10^{-7}	7×10^{-12}	na ^b	2×10^{-12}	9×10^{-12}
Ethylbenzene	1.9	8.8×10^{-8}	na ^b	na ^c	0.011	na	1×10^{-9}	na ^b	na ^c	1×10^{-9}
Trichloroethene	0.16	7.4×10^{-9}	na ^b	1.5×10^{-5}	0.13	2×10^{-5}	1×10^{-9}	na ^b	3×10^{-10}	1×10^{-9}
Vinyl chloride	1.2	5.5×10^{-8}	na ^b	1.7×10^{-3}	0.72	4.4×10^{-6}	4×10^{-8}	na ^b	8×10^{-9}	5×10^{-8}
TPH-gasoline (aliphatic)	430	2.0×10^{-5}	na ^b	1.5×10^{-1}	na	1.9×10^{-7}	na ^a	na ^a	3×10^{-8}	3×10^{-8}
Total excess cancer risk across exposure routes										3×10^{-6}

^a No cancer slope factor is available, and thus the excess cancer risk based on incidental ingestion and dermal absorption cannot be calculated.

^b No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^c Per EPA guidance, the carcinogenic risk from the inhalation pathway was not assessed for ethylbenzene (EPA 2010c).

CDI – chronic daily intake

dw – dry weight

na – not applicable or available

COPC – contaminant of potential concern

EC – exposure concentration

PCB – polychlorinated biphenyl

cPAH – carcinogenic polycyclic aromatic hydrocarbon

EPA – US Environmental Protection Agency

TEQ – toxic equivalent

DDT – dichlorodiphenyltrichloroethane

EPC – exposure point concentration

TPH – total petroleum hydrocarbons

Table 5-2. Excess Cancer Risk Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Groundwater

Scenario timeframe: Current/future Medium: Groundwater Receptor population: Workers Receptor age: Adult								
COPC	EPC (mg/kg dw)	Cancer CDI for Dermal Absorption (mg/kg-day)	Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)	Cancer Slope Factor (mg/kg-day) ⁻¹	Inhalation Unit Risk Factor ($\mu\text{g}/\text{m}^3$) ⁻¹	Excess Cancer Risk		
						Dermal Absorption	Inhalation	Total
Arsenic (total) ^a	0.015	2.9×10^{-8}	na ^b	1.5	na ^b	4×10^{-8}	na ^b	4×10^{-8}
Naphthalene	0.00033	1.9×10^{-7}	2.8×10^{-10}	na	3.4×10^{-5}	na ^d	9×10^{-15}	9×10^{-15}
1,4-Dichlorobenzene	0.0014	1.9×10^{-7}	1.7×10^{-9}	0.0054	1×10^{-5}	1×10^{-9}	2×10^{-14}	1×10^{-9}
Total DDTs	0.000049	1.1×10^{-7}	1.5×10^{-12}	0.34	9.7×10^{-5}	4×10^{-8}	2×10^{-16}	4×10^{-8}
Benzene	0.039	na ^c	4.8×10^{-8}	0.055	7.8×10^{-6}	na ^c	4×10^{-13}	4×10^{-13}
tert-Butyl methyl ether	0.028	na ^c	2.9×10^{-8}	0.0018	3×10^{-7}	na ^c	9×10^{-15}	9×10^{-15}
Vinyl chloride	0.0005	na ^c	8.1×10^{-11}	0.72	4.4×10^{-6}	na ^c	4×10^{-16}	4×10^{-16}
Total excess cancer risk across exposure routes								8×10^{-8}

^a Both the total and dissolved fraction were greater than the screening level. To be conservative, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

^b This COPC is not expected to volatilize significantly because of its diffusivity in air or water, and thus risks based on inhalation are not assessed here.

^c No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^d No cancer slope factor is available for this COPC, and thus the excess cancer risk based on dermal absorption cannot be calculated.

CDI – chronic daily intake

dw – dry weight

HHRA – human health risk assessment

COPC – contaminant of potential concern

EC – exposure concentration

na – not applicable or available

DDT – dichlorodiphenyltrichloroethane

EPC – exposure point concentration

Table 5-3. Non-Cancer Hazard Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Facility Soil

Scenario timeframe: Current/future Medium: Facility soil Receptor population: Workers Receptor age: Adult										
COPC	EPC (mg/kg dw)	Non-Cancer CDI (mg/kg-day)		Non-Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)	Reference Dose (mg/kg-day)	Reference Concentration (mg/m^3)	Hazard Quotient			
		Incidental Ingestion	Dermal Absorption				Incidental Ingestion	Dermal Absorption	Inhalation	Total
Arsenic	8.3	2.7×10^{-5}	8.0×10^{-6}	3.6×10^{-7}	0.0003	0.000015	0.09	0.03	0.00002	0.1
Cobalt	13	4.2×10^{-5}	na ^a	5.6×10^{-7}	0.0003	0.000006	0.1	na ^a	0.00009	0.1
Copper	270	8.7×10^{-4}	na ^a	1.2×10^{-5}	0.04	na	0.02	na ^a	na ^b	0.02
Naphthalene	2.0	6.5×10^{-6}	8.4×10^{-6}	4.3×10^{-5}	0.02	0.003	0.0003	0.0004	0.00001	0.0007
Total PCBs	3.4	1.1×10^{-5}	1.5×10^{-5}	6.0×10^{-7}	0.00002	na	0.5	0.8	na ^b	1
Total DDTs	11	3.6×10^{-5}	1.1×10^{-5}	4.8×10^{-7}	0.0005	na	0.07	0.02	na ^b	0.09
1,1-Dichloroethane	0.68	2.2×10^{-6}	na ^a	9.7×10^{-3}	0.2	0.5	0.00001	na ^a	0.00002	0.00003
1,2,4-Trimethylbenzene	5.3	1.7×10^{-5}	na ^a	1.1×10^{-4}	0.05	0.007	0.0003	na ^a	0.00002	0.0003
1,3,5-Trimethylbenzene	1.3	4.2×10^{-6}	na ^a	2.8×10^{-5}	0.05	0.006	0.00008	na ^a	0.000005	0.00009
Benzene	0.33	1.1×10^{-6}	na ^a	3.4×10^{-3}	0.004	0.03	0.0003	na ^a	0.0001	0.0004
Chlorobenzene	0.22	7.1×10^{-7}	na ^a	2.7×10^{-3}	0.02	0.05	0.00004	na ^a	0.00005	0.00009
cis-1,2-Dichloroethene	8.7	2.8×10^{-5}	na ^a	8.6×10^{-2}	0.01	na	0.003	na ^a	na ^b	0.003
Dichloromethane	0.02	6.5×10^{-8}	na ^a	3.0×10^{-4}	0.06	na	0.000001	na ^a	na ^b	0.000001
Ethylbenzene	1.9	6.1×10^{-6}	na ^a	4.5×10^{-3}	0.1	1	0.00006	na ^a	0.000005	0.00007
trans-1,2-Dichloroethene	5.5	1.8×10^{-5}	na ^a	8.0×10^{-2}	0.02	0.06	0.0009	na ^a	0.001	0.002
Vinyl chloride	1.2	3.9×10^{-6}	na ^a	1.2×10^{-1}	0.003	0.1	0.001	na ^a	0.001	0.002
Total xylenes	10	3.2×10^{-5}	na ^a	3.0×10^{-2}	0.2	0.1	0.0002	na ^a	0.0003	0.0005
TPH-gasoline (aliphatic)	430	1.4×10^{-3}	na ^a	1.1×10^1	0.3	0.6	0.005	na ^a	0.02	0.02
Overall HI across all exposure routes/pathways^c										1

^a No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^b No RfC is available for these COPCs, and thus HQs from inhalation cannot be calculated.

^c The overall HI is equal to the sum of HQs for all COPCs across multiple endpoints and/or target organs. If the overall HI did not exceed 1, then endpoint-specific HIs were not calculated because they would be less than 1 as well.

CDI – chronic daily intake
 COPC – contaminant of potential concern
 DDT – dichlorodiphenyltrichloroethane
 dw – dry weight

EC – exposure concentration
 EPC – exposure point concentration
 HI – hazard index
 HQ – hazard quotient

na – not applicable or available
 PCB – polychlorinated biphenyl
 RfC – reference concentration
 TPH – total petroleum hydrocarbons

Table 5-4. Non-Cancer Hazard Estimates for the Industrial (Construction/Trenching) Worker Scenario Based on Exposure to Groundwater

Scenario timeframe: Current/future Medium: Groundwater Receptor population: Workers Receptor age: Adult								
COPC	EPC (mg/kg dw)	Non-Cancer CDI for Dermal Absorption (mg/kg-day)	Non-Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)	Reference Dose (mg/kg-day)	Reference Concentration (mg/m^3)	Hazard Quotient		
						Dermal Absorption	Inhalation	Total
Arsenic (total) ^a	0.015	2.1×10^{-6}	na ^b	0.0003	0.000015	0.007	na ^b	0.007
Manganese (total) ^a	4.0	na ^c	na ^b	0.14	0.000006	na ^c	na ^b	na
Naphthalene	0.00033	1.4×10^{-5}	1.9×10^{-8}	0.02	0.003	0.0007	0.000000006	0.0007
1,4-Dichlorobenzene	0.0014	1.4×10^{-5}	1.2×10^{-7}	0.07	0.8	0.0002	0.0000000001	0.0002
Total DDTs	0.000049	8.0×10^{-6}	1.1×10^{-10}	0.0005	na	0.02	na ^b	0.02
1,2,4-Trimethylbenzene	0.0072	na ^c	4.3×10^{-7}	0.05	0.007	na ^c	0.00000006	0.00000006
1,3,5-Trimethylbenzene	0.003	na ^c	1.8×10^{-7}	0.05	0.006	na ^c	0.00000003	0.00000003
Benzene	0.039	na ^c	3.4×10^{-6}	0.004	0.03	na ^c	0.0000001	0.0000001
Chlorobenzene	0.08	na ^c	6.3×10^{-6}	0.02	0.05	na ^c	0.0000001	0.0000001
n-Propylbenzene	0.011	na ^c	7.4×10^{-7}	0.1	1	na ^c	0.0000000007	0.0000000007
tert-Butyl methyl ether	0.028	na ^c	2.1×10^{-6}	na	3	na ^c	0.0000000007	0.0000000007
Vinyl chloride	0.0005	na ^c	5.7×10^{-9}	0.003	0.1	na ^c	0.00000000006	0.00000000006
Overall HI across all exposure routes/pathways^d								0.03

^a Both the total and dissolved fraction were greater than the screening level. As a conservative assumption, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

^b This COPC is not expected to volatilize significantly because of its diffusivity in air or water, and thus risks based on inhalation are not assessed here.

^c No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^d The overall HI is equal to the sum of HQs for all COPCs across multiple endpoints and/or target organs. If the overall HI did not exceed 1, then endpoint-specific HIs were not calculated because they would be less than 1 as well.

CDI – chronic daily intake

EC – exposure concentration

HQ – hazard quotient

COPC – contaminant of potential concern

EPC – exposure point concentration

na – not applicable or available

DDT – dichlorodiphenyltrichloroethane

HHRA – human health risk assessment

RfC – reference concentration

dw – dry weight

HI – hazard index

While no individual COPCs had an excess cancer risk greater than 1×10^{-6} , the estimated total excess cancer risk was equal to 3×10^{-6} . Cancer risk estimates for arsenic, cPAH TEQ, and total PCBs together accounted for over 80% of the total excess cancer risk (Table 5-1). The total PCB HQ based on exposure to soil was equal to, but not greater than 1. No COPCs had non-cancer HQs greater than 1. Based on the risk estimates and HQs, no COCs were identified for this scenario.

In addition to evaluating risks separately by media, the risks presented in Tables 5-1 through 5-4 can be combined based on exposure to both soil and groundwater. Table 5-5 presents these total risk estimates for this scenario.

Table 5-5. Excess Cancer Risk Estimates Across Scenarios

Scenario	Excess Cancer Risk	Hazard Quotient
Exposure to Facility soil	3×10^{-6}	1
Exposure to groundwater	8×10^{-8}	0.03
Total risk estimate across media	3×10^{-6}	1

As shown in Table 5-5, the total excess cancer risk was equal to 3×10^{-6} , attributable almost entirely to exposure to Facility soil. The overall HI was equal to, but did not exceed 1, and thus endpoint-specific HIs were not calculated.

To further evaluate the total excess cancer risk based on exposure to Facility soil, background or reference area excess cancer risks for the industrial (construction/trenching) worker based on exposure to Facility soil were calculated (Table 5-6). Background or reference area risk estimates were calculated for those COPCs contributing the majority of the risk (shown as excess cancer risk in Table 5-6). The background soil concentrations used for this comparison were based on recommended DEQ default background concentrations for metals. For other organic compounds, reference area soil concentrations were based on concentrations reported at nearby sites (Attachment 7); specific regulatory background soil concentrations have not been established. Risks from groundwater are shown in this table for completeness, but an evaluation of background or reference area groundwater risks was not conducted because of the low risks calculated based on exposure to this medium.

Table 5-6. Comparison of Study Area and Background or Reference Area Soil Exposure Concentrations and Risk Estimates for the Industrial (Construction/Trenching) Worker RME Scenario

Media	COPC	Soil Exposure Concentration (mg/kg dw)		Excess Cancer Risk	
		Study Area	Background or Reference Area ^a	Study Area	Background or Reference Area ^a
Facility Soil	Arsenic	8.3	7	8×10^{-7}	6×10^{-7}
	cPAH TEQ	0.95	0.0082 to 0.056	7×10^{-7}	6×10^{-9} to 4×10^{-8}
	Total PCBs	3.4	0.023 to 0.024 ^b	7×10^{-7}	5×10^{-9}
	Other COPCs	na	na	4×10^{-7}	ne
Ground-water	All COPCs	na	na	8×10^{-8}	ne
Total excess cancer risk				3×10^{-6}	na

^a Background and reference area concentrations and sources are discussed in Attachment 7. Concentrations for metals are representative of background concentrations and concentrations for organic compounds are representative of reference area concentrations (i.e., concentrations in urban areas in the vicinity of the Study Area).

^b No soil reference area concentrations were available. The concentrations presented here are sediment reference area concentrations, as discussed in Attachment 7.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

na – not applicable

RME – reasonable maximum exposure

ne – not evaluated

TEQ – toxic equivalent

As shown in Table 5-6, the Study Area excess cancer risk estimate for arsenic was less than 1×10^{-6} and was similar to the risk estimate based on background (8×10^{-7} vs. 6×10^{-7}). The reference area risks for total PCBs and cPAH TEQ were 18 to 140 times lower than Study Area risks.

5.3.2 Future Outdoor Worker

This section presents cancer and non-cancer risks to future outdoor workers associated with exposure to Facility soil. The estimated excess cancer risk was equal to 2×10^{-5} (Table 5-7). The sum of non-cancer HQs was less than 1 (equal to 0.6) (Table 5-8).

Table 5-7. Excess Cancer Risk Estimates for the Future Outdoor Worker RME Scenario

Scenario timeframe: Future Medium: Facility soil Receptor population: Workers Receptor age: Adult										
COPC	EPC (mg/kg dw)	Cancer CDI (mg/kg-day)		Cancer EC ($\mu\text{g}/\text{m}^3$)	Cancer Slope Factor (mg/kg-day) ⁻¹	Inhalation Unit Risk Factor ($\mu\text{g}/\text{m}^3$) ⁻¹	Excess Cancer Risk			
		Incidental Ingestion	Dermal Absorption	Inhalation			Incidental Ingestion	Dermal Absorption	Inhalation	Total
Arsenic	11	3.8×10^{-6}	3.8×10^{-7}	6.8×10^{-7}	1.5	0.0043	6×10^{-6}	6×10^{-7}	3×10^{-9}	7×10^{-6}
cPAH TEQ	1.1	3.8×10^{-7}	1.6×10^{-7}	6.8×10^{-8}	7.3	0.001	3×10^{-6}	1×10^{-6}	7×10^{-11}	4×10^{-6}
Total PCBs	5.2	1.8×10^{-6}	8.4×10^{-7}	1.3×10^{-6}	2	0.0001	4×10^{-6}	2×10^{-6}	1×10^{-10}	6×10^{-6}
Total DDTs	16	5.6×10^{-6}	5.5×10^{-7}	9.9×10^{-7}	0.34	0.000097	2×10^{-6}	2×10^{-7}	1×10^{-10}	2×10^{-6}
1,1-Dichloroethane	0.68	2.4×10^{-7}	na ^b	1.4×10^{-2}	0.0057	1.6×10^{-6}	1×10^{-9}	na ^b	2×10^{-8}	2×10^{-8}
Benzene	0.51	1.8×10^{-7}	na ^b	7.6×10^{-3}	0.055	7.8×10^{-6}	1×10^{-8}	na ^b	6×10^{-8}	7×10^{-8}
Dichloromethane	0.047	1.6×10^{-8}	na ^b	9.8×10^{-4}	0.0075	4.7×10^{-7}	1×10^{-10}	na ^b	5×10^{-10}	6×10^{-10}
Ethylbenzene	3.1	1.1×10^{-6}	na ^b	1.1×10^{-2}	0.011	na	1×10^{-8}	na ^b	na ^c	1×10^{-8}
Trichloroethene	0.27	9.4×10^{-8}	na ^b	2.5×10^{-3}	0.13	0.00002	1×10^{-8}	na ^b	5×10^{-8}	6×10^{-8}
Vinyl chloride	1.2	4.2×10^{-7}	na ^b	1.7×10^{-1}	0.72	4.4×10^{-6}	3×10^{-7}	na ^b	8×10^{-7}	1×10^{-6}
TPH-gasoline (aliphatic)	660	2.3×10^{-4}	na ^b	1.5×10^1	na	1.9×10^{-7}	na ^a	na ^a	3×10^{-6}	3×10^{-6}
Total excess cancer risk across exposure routes										2×10^{-5}

^a No cancer slope factor is available for this COPC, and thus the excess cancer risk based on incidental ingestion and dermal absorption cannot be calculated.

^b No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^c Per EPA guidance, the carcinogenic risk from the inhalation pathway was not assessed for ethylbenzene (EPA 2010c).

CDI – chronic daily intake

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

EC – exposure concentration

EPA – US Environmental Protection Agency

EPC – exposure point concentration

dw – dry weight

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

Table 5-8. Non-Cancer Hazard Estimates for the Future Outdoor Worker RME Scenario

Scenario timeframe: Future Medium: Facility soil Receptor population: Workers Receptor age: Adult										
COPC	EPC (mg/kg dw)	Non-Cancer CDI (mg/kg-day)		Non-Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)	Reference Dose (mg/kg-day)	Reference Concentration (mg/m^3)	Hazard Quotient			
		Incidental Ingestion	Dermal Absorption				Incidental Ingestion	Dermal Absorption	Inhalation	Total
Arsenic	11	1.1×10^{-5}	1.1×10^{-6}	1.9×10^{-6}	0.0003	0.000015	0.04	0.004	0.0001	0.04
Cobalt	14	1.4×10^{-5}	na ^a	2.4×10^{-6}	0.0003	0.000006	0.05	na ^a	0.0004	0.05
Copper	150	1.5×10^{-4}	na ^a	2.6×10^{-5}	0.04	na	0.004	na ^a	na ^b	0.004
Naphthalene	2.6	2.5×10^{-6}	1.1×10^{-6}	2.2×10^{-4}	0.02	0.003	0.00013	0.00005	0.00007	0.0002
Total PCBs	5.2	5.1×10^{-6}	2.4×10^{-6}	3.6×10^{-6}	0.00002	na	0.3	0.12	na ^b	0.4
Total DDTs	16	1.6×10^{-5}	1.5×10^{-6}	2.8×10^{-6}	0.0005	na	0.03	0.003	na ^b	0.03
1,1-Dichloroethane	0.68	6.7×10^{-7}	na ^a	3.9×10^{-2}	0.2	0.5	0.000003	na ^a	0.00008	0.00008
1,2,4-Trimethylbenzene	13	1.3×10^{-5}	na ^a	1.1×10^{-3}	0.05	0.007	0.0003	na ^a	0.0002	0.0005
1,3,5-Trimethylbenzene	3	2.9×10^{-6}	na ^a	2.5×10^{-4}	0.05	0.006	0.00006	na ^a	0.00004	0.0001
Benzene	0.51	5.0×10^{-7}	na ^a	2.1×10^{-2}	0.004	0.03	0.0001	na ^a	0.0007	0.0008
cis-1,2-Dichloroethene	130	1.3×10^{-4}	na ^a	$5.0 \times 10^{+0}$	0.01	na	0.01	na ^a	na ^b	0.01
Dichloromethane	0.047	4.6×10^{-8}	na ^a	2.7×10^{-3}	0.06	na	0.0000008	na ^a	na ^b	0.0000008
Ethylbenzene	3.1	3.0×10^{-6}	na ^a	3.0×10^{-2}	0.1	1	0.00003	na ^a	0.00003	0.00006
trans-1,2-Dichloroethene	5.5	5.4×10^{-6}	na ^a	3.2×10^{-1}	0.02	0.06	0.0003	na ^a	0.005	0.005
Vinyl chloride	1.2	1.2×10^{-6}	na ^a	4.8×10^{-1}	0.003	0.1	0.0004	na ^a	0.005	0.005
Total xylenes	16	1.6×10^{-5}	na ^a	1.9×10^{-1}	0.2	0.1	0.00008	na ^a	0.002	0.002
TPH-gasoline (aliphatic)	660	6.5×10^{-4}	na ^a	4.3×10^1	0.3	0.6	0.002	na ^a	0.07	0.07
Overall HI across all exposure routes/pathways^c										0.6

^a No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^b No RfC is available for these COPCs, and thus HQs from inhalation cannot be calculated.

^c The overall HI is equal to the sum of HQs for all COPCs across multiple endpoints and/or target organs. If the overall HI did not exceed 1, then endpoint-specific HIs were not calculated because they would be less than 1 as well.

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EC – exposure concentration

EPC – exposure point concentration

HI – hazard index

HQ – hazard quotient

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TPH – total petroleum hydrocarbons

Excess cancer risk estimates for arsenic, cPAH TEQ, total PCBs, total DDTs, and TPH-gasoline (aliphatic) individually were greater than 1×10^{-6} , and thus were identified as COCs. Together they accounted for nearly all of the total excess cancer risk. Arsenic, cPAH TEQ, and total PCBs, total DDTs, and TPH-gasoline (aliphatic) accounted for approximately 30, 17, 26, 9, and 13%, respectively, of the total excess cancer risk.

To further evaluate the total excess cancer risk, background or reference area excess cancer risks for the future outdoor worker based on exposure to soil were calculated (Table 5-9).

Table 5-9. Comparison of Study Area and Background or Reference Area Soil Exposure Concentrations and Excess Cancer Risk Estimates for the Future Outdoor Worker Scenario Based on Exposure to Facility Soil

COPC	Soil Exposure Concentration (mg/kg dw)		Excess Cancer Risk	
	Study Area	Background or Reference Area ^a	Study Area	Background or Reference Area ^a
Arsenic	11	7	7×10^{-6}	4×10^{-6}
cPAH TEQ	1.1	0.0082 to 0.056	4×10^{-6}	3×10^{-8} to 2×10^{-7}
Total PCBs	5.2	0.023 to 0.024 ^b	6×10^{-6}	2×10^{-8}
Total DDTs	16	0.015 to 0.355	2×10^{-6}	2×10^{-9} to 5×10^{-8}
TPH-gasoline (aliphatic)	660	ne	3×10^{-6}	ne
Other COPCs	na	na	1×10^{-6}	na
Total risk			2×10^{-5}	na

^a Background or reference area concentrations and sources are discussed in Attachment 7. Concentrations for metals are representative of background concentrations, and concentrations for organic compounds are representative of reference area concentrations (i.e., concentrations in urban areas in the vicinity of the Study Area).

^b No soil reference area concentrations were available. The concentrations presented here are sediment reference area concentrations, as discussed in Attachment 7.

COPC – contaminant of potential concern ne – not evaluated
cPAH – carcinogenic polycyclic aromatic hydrocarbon PCB – polychlorinated biphenyl
DDT – dichlorodiphenyltrichloroethane TEQ – toxic equivalent
na – not applicable TPH – total petroleum hydrocarbons

As shown in Table 5-9, the background arsenic concentration (7 mg/kg dw) was over half of the value of the Study Area exposure concentration (11 mg/kg dw) and was greater than 85% of the Facility soil concentrations included as part of the exposure area for this scenario. Thus the consideration of background is important when evaluating the excess cancer risk estimate associated with arsenic. For cPAH TEQ, total PCBs, and total DDTs, the excess cancer risks calculated using reference area concentrations were 6 to 1,000 times lower than Study Area risk estimates.

5.3.3 Industrial/Commercial Worker Vapor Intrusion

This section presents risks to workers at the Study Area associated with the intrusion of vapors into buildings at the Facility. Note that this scenario looks at exposure from COPCs via vapor intrusion, not overall risks associated with operations on the Facility.

5.3.3.1 Current Facility Buildings

Risks associated with vapor intrusion into buildings were calculated using groundwater screening levels provided in EPA's draft guidance (2002c). These screening levels were calculated using a target excess cancer risk of 1×10^{-6} (i.e., concentrations below these screening levels would equate to an excess cancer risk lower than 1×10^{-6}) and using default exposure parameters protective of residential exposure, even though this scenario is based worker exposure.¹⁴ The main differences between residential and worker exposure parameters are the assumed exposure frequency and the duration (350 days/year for 30 years for residential exposure as compared with 250 days/year for 25 years for worker exposure). Thus, risks to workers would be lower than those presented here.

The groundwater vapor intrusion screening levels in EPA's guidance (2002c) were calculated based on the equations presented in EPA's *Supplemental Guidance for Developing Soil Screening Levels* (2002d). These calculations differ slightly from those presented in EPA's RAGS Part F: Supplemental Guidance for Inhalation Risk Assessment (2009j), which provides updated methodologies for the calculation of risks from inhalation. Specifically, exposure time (i.e., hours per day) was not considered in the 2002 methodology. Because no new vapor intrusion screening levels are available, the EPA (2002c) screening levels were used for this assessment.

Groundwater concentrations of all chemicals were less than the screening levels. Nevertheless, two COPCs (benzene and vinyl chloride) were identified for this scenario because of their status as Class A carcinogens, per EPA direction. Excess cancer risks for these two COPCs were derived by dividing the EPC by the screening level and multiplying the result by 1×10^{-6} (i.e., the target risk level used to calculate the screening levels) (Table 5-10).

¹⁴ Default exposure parameters, as presented in EPA (2002c), include an exposure duration of 30 years, an exposure frequency of 350 days per year, an inhalation rate of 20 m³/day, and a body weight of 70 kg. Toxicity values used in the calculation of these 2002 screening levels are consistent with toxicity values for benzene and vinyl chloride in IRIS.

Table 5-10. Risk Estimates for the Industrial/Commercial Worker Vapor Intrusion Scenario

COPC	EPC (µg/L)	EPA Vapor Intrusion SL (2002c) (µg/L)	Excess Cancer Risk
Benzene	3.1	5.0	6×10^{-7}
Vinyl chloride	0.5	2.0	3×10^{-7}
Total excess cancer risk			9×10^{-7}

COPC – contaminant of potential concern

EPA – US Environmental Protection Agency

EPC – exposure point concentration

RL – reporting limit

SL – screening level

As presented in Table 5-10, the total excess cancer risk was equal to 9×10^{-7} , less than the lower end of EPA's target risk range. Furthermore, as noted previously, risks to occupational workers would likely be lower than the risks presented in Table 5-10 because the screening levels used to calculate these risks were based on residential exposures, which assume a higher exposure potential than that for workers.

5.3.3.2 Hypothetical/Future Facility Buildings

In addition to the evaluation of risks associated with vapor intrusion to current Facility buildings (Section 5.3.3.1), risks to workers associated with hypothetical exposures in future buildings at the Facility were also examined. Because the sizes and locations of future buildings are unknown, all shallow groundwater samples not included in the current Facility building assessment were compared with the vapor intrusion screening levels. The same two COPCs (benzene and vinyl chloride) were identified based on their Class A carcinogen status, and concentrations were compared with screening levels. Concentrations were less than screening levels with one exception: benzene was detected at a concentration greater than the screening level at location MW-4s in 2008 (140 µg/L versus a screening level of 5.0 µg/L). In the sample collected at the same location a year later, benzene was detected at a concentration of 2.9 µg/L, less than the screening level. Thus, although the concentration based on the single sample from MW-4s in 2008 could result in a risk greater than 1×10^{-6} if a building were built and occupied at this location, risks are unlikely to be greater than 1×10^{-6} if multiple samples over a longer time period or covering the area of a hypothetical future building were considered.

Based on this analysis, risks would be expected to be low (less than 1×10^{-6}) for workers if additional buildings were to be constructed at the Facility. No COCs were identified for the Industrial/Commercial Worker Vapor Intrusion scenario.

5.3.4 Force Lake Recreational User

This section presents cancer and non-cancer risks associated with exposure to wetland soil, lake sediment, and lake surface water. Risks were calculated for the total exposure duration of 30 years, ranging from birth to age 30 to include the most sensitive life stage in a lifetime scenario (as discussed in Section 5.1). Excess cancer risks based on exposure to wetland soil, lake sediment, and lake surface water are presented in Tables 5-11 to 5-13.

The excess cancer risk based on exposure to wetland soil (9×10^{-6}) was higher than the lower end of EPA's target risk range (1×10^{-6}). The excess cancer risk based on exposures to lake sediment or lake surface water were less than or equal to 1×10^{-6} .

Table 5-11. Cumulative Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario Based on Exposure to Wetland Soil

Scenario timeframe: Current/future							
Medium: Wetland soil							
Receptor population: Visitors							
Receptor age: Child and adult (aged 0 to 30)							
COPC	EPC (mg/kg dw)	Cancer CDI (mg/kg-day)		Cancer Slope Factor (mg/kg-day) ⁻¹	Excess Cancer Risk		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Arsenic	9.6	1.3×10^{-6}	1.5×10^{-7}	1.5	2×10^{-6}	2×10^{-7}	2×10^{-6}
cPAH TEQ	1.1	1.5×10^{-7}	7.7×10^{-8}	7.3	4×10^{-6}	2×10^{-6}	6×10^{-6}
Total PCBs	0.77	1.0×10^{-7}	5.8×10^{-8}	2	2×10^{-7}	1×10^{-7}	3×10^{-7}
Total DDTs	9.1	1.2×10^{-6}	1.5×10^{-7}	0.34	4×10^{-7}	5×10^{-8}	5×10^{-7}
Benzene	0.0077	1.0×10^{-9}	na ^a	0.055	6×10^{-11}	na ^a	6×10^{-11}
Trichloroethene	0.0075	1.0×10^{-9}	na ^a	0.013	1×10^{-10}	na ^a	1×10^{-10}
Total excess cancer risk across exposure routes							9×10^{-6}

^a No dermal absorption factor was available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

CDI – chronic daily intake

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EPC – exposure point concentration

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TEQ – toxic equivalent

Table 5-12. Cumulative Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Sediment

Scenario timeframe: Current/future							
Medium: Lake sediment							
Receptor population: Visitors							
Receptor age: Child and adult (aged 0 to 30)							
COPC	EPC (mg/kg dw)	Cancer CDI (mg/kg-day)		Cancer Slope Factor (mg/kg-day) ⁻¹	Excess Cancer Risk		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Arsenic	6.4	8.5×10^{-7}	1.0×10^{-7}	1.5	1×10^{-6}	2×10^{-7}	1×10^{-6}
cPAH TEQ	0.081	1.1×10^{-8}	5.6×10^{-9}	7.3	3×10^{-7}	1×10^{-7}	4×10^{-7}
Total excess cancer risk across exposure routes							1×10^{-6}

CDI – chronic daily intake

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

dw – dry weight

EPC – exposure point concentration

RME – reasonable maximum exposure

TEQ – toxic equivalent

Table 5-13. Cumulative Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Surface Water

Scenario timeframe: Current/future							
Medium: Lake surface water							
Receptor population: Visitors							
Receptor age: Child and adult (aged 0 to 30)							
COPC	EPC (mg/L)	Cancer CDI (mg/kg-day)		Cancer Slope Factor (mg/kg-day) ⁻¹	Excess Cancer Risk		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Arsenic (total) ^a	0.0012	9.3×10^{-8}	8.1×10^{-9}	1.5	1×10^{-7}	1×10^{-8}	1×10^{-7}
Total excess cancer risk across exposure routes							1×10^{-7}

^a Both the total and dissolved fractions were greater than the screening level. To be conservative, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

CDI – chronic daily intake

COPC – contaminant of potential concern

EPC – exposure point concentration

HHRA – human health risk assessment

RME – reasonable maximum exposure

HQs for child exposure (0 to 6 year age class) are presented in Tables 5-14 to 5-16 for the three recreational scenarios. For risk communication purposes, the weighted average HQs for the 30-yr exposure duration are also presented (Tables 5-17 to 5-19). These HQs are lower than those for the 0-to-6 year age group, and are not typically used for risk management decisions. They are presented here for risk communication purposes only.

The overall HI was less than 1 for all media for children aged 0 to 6 (the most sensitive age group). The overall HI for the 30-yr exposure duration, presented as a weighted average, was a factor of 3 to 4 times lower than the overall HI for children aged 0 to 6.

Table 5-14. Non-Cancer Hazard Estimates for the Force Lake Recreational User RME Scenario Based on the Exposure of Children Aged 0 to 6 to Wetland Soil

Scenario timeframe: Current/future							
Medium: Wetland soil							
Receptor population: Visitors							
Receptor age: Child (aged 0 to 6)							
COPC	EPC (mg/kg dw)	Non-Cancer CDI (mg/kg-day)		Reference Dose (mg/kg-day)	Hazard Quotient		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Aluminum	12,000	1.1×10^{-2}	na ^a	1	0.01	na ^a	0.01
Antimony	1.1	9.9×10^{-7}	na ^a	0.0004	0.002	na ^a	0.002
Arsenic	9.6	8.6×10^{-6}	5.2×10^{-7}	0.0003	0.03	0.002	0.03
Chromium	37	3.3×10^{-5}	na ^a	1.5	0.00002	na ^a	0.00002
Cobalt	12	1.1×10^{-5}	na ^a	0.0003	0.04	na ^a	0.04
Copper	160	1.4×10^{-4}	na ^a	0.04	0.004	na ^a	0.004
Iron	57,000	5.1×10^{-2}	na ^a	0.7	0.07	na ^a	0.07
Manganese	1,100	9.9×10^{-4}	na ^a	0.14	0.007	na ^a	0.007
Vanadium	76	6.8×10^{-5}	na ^a	0.005	0.01	na ^a	0.01
Naphthalene	0.64	5.7×10^{-7}	1.5×10^{-7}	0.02	0.00003	0.000007	0.00004
Total PCBs	0.77	6.9×10^{-7}	1.9×10^{-7}	0.00002	0.03	0.01	0.04
Total DDTs	9.1	8.2×10^{-6}	4.9×10^{-7}	0.0005	0.02	0.001	0.02
Benzene	0.0077	6.9×10^{-9}	na ^a	0.004	0.000002	na ^a	0.000002
TPH-gasoline (aliphatic)	25	2.2×10^{-5}	na ^a	0.3	0.00007	na ^a	0.00007
TPH-diesel (aliphatic)	780	7.0×10^{-4}	na ^a	0.01	0.07	na ^a	0.07
Overall HI across all exposure routes/pathways^b							0.3

^a No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^b The overall HI is equal to the sum of HQs across multiple endpoints and/or target organs. The value indicates that the HI could not exceed 1 for individual endpoints. Therefore, HIs were not calculated for individual endpoints.

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EPC – exposure point concentration

HI – hazard index

HQ – hazard quotient

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TPH – total petroleum hydrocarbons

Table 5-15. Non-Cancer Hazard Estimates for the Force Lake Recreational User RME Scenario Based on the Exposure of Children Aged 0 to 6 to Lake Sediment

Scenario timeframe: Current/future							
Medium: Lake sediment							
Receptor population: Visitors							
Receptor age: Child (aged 0 to 6)							
COPC	EPC (mg/kg dw)	Non-Cancer CDI (mg/kg-day)		Reference Dose (mg/kg-day)	Hazard Quotient		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Arsenic	6.4	5.7×10^{-6}	3.4×10^{-7}	0.0003	0.02	0.001	0.02
Chromium	30	2.7×10^{-5}	na ^a	1.5	0.00002	na ^a	0.00002
Cobalt	14	1.3×10^{-5}	na ^a	0.0003	0.04	na ^a	0.04
Vanadium	67	6.0×10^{-5}	na ^a	0.005	0.01	na ^a	0.01
TPH-gasoline (aliphatic)	34	3.1×10^{-5}	na ^a	0.3	0.0001	na ^a	0.0001
Overall HI across all exposure routes/pathways^b							0.07

^a No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^b The overall HI is equal to the sum of HQs across multiple endpoints and/or target organs. The value indicates that the HI could not exceed 1 for individual endpoints. Therefore, HIs were not calculated for individual endpoints.

CDI – chronic daily intake

HQ – hazard quotient

COPC – contaminant of potential concern

na – not applicable

dw – dry weight

RME – reasonable maximum exposure

EPC – exposure point concentration

TPH – total petroleum hydrocarbons

HI – hazard index

Table 5-16. Non-Cancer Hazard Estimates for the Force Lake Recreational User RME Scenario Based on the Exposure of Children Aged 0 to 6 to Lake Surface Water

Scenario timeframe: Current/future							
Medium: Lake surface water							
Receptor population: Visitors							
Receptor age: Child (aged 0 to 6)							
COPC	EPC (mg/L)	Non-Cancer CDI (mg/kg-day)		Reference Dose (mg/kg-day)	Hazard Quotient		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Arsenic (total) ^a	0.0012	4.6×10^{-7}	1.8×10^{-8}	0.0003	0.002	0.00006	0.002

^a Both the total and dissolved fraction were greater than the screening level. To be conservative, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

CDI – chronic daily intake

HHRA – human health risk assessment

COPC – contaminant of potential concern

HI – hazard index

EPC – exposure point concentration

HQ – hazard quotient

Table 5-17. Weighted Non-Cancer Hazard Estimates for 0 to 30-yr Exposure Duration for the Force Lake Recreational User RME Scenario Based on Exposure to Wetland Soil

Scenario timeframe: Current/future							
Medium: Wetland soil							
Receptor population: Visitors							
Receptor age: Child and adult (aged 0 to 30)							
COPC	EPC (mg/kg dw)	Non-Cancer CDI (mg/kg-day)		Reference Dose (mg/kg-day)	Hazard Quotient		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Aluminum	12,000	3.7×10^{-3}	na ^a	1	0.004	na ^a	0.004
Antimony	1.1	3.4×10^{-7}	na ^a	0.0004	0.0009	na ^a	0.0009
Arsenic	9.6	3.0×10^{-6}	3.6×10^{-7}	0.0003	0.01	0.001	0.01
Chromium	37	1.1×10^{-5}	na ^a	1.5	0.000008	na ^a	0.000008
Cobalt	12	3.7×10^{-6}	na ^a	0.0003	0.01	na ^a	0.01
Copper	160	5.0×10^{-5}	na ^a	0.04	0.001	na ^a	0.001
Iron	57,000	1.8×10^{-2}	na ^a	0.7	0.03	na ^a	0.03
Manganese	1,100	3.4×10^{-4}	na ^a	0.14	0.002	na ^a	0.002
Vanadium	76	2.4×10^{-5}	na ^a	0.005	0.005	na ^a	0.005
Naphthalene	0.64	2.0×10^{-7}	1.0×10^{-7}	0.02	0.00001	0.000005	0.00002
Total PCBs	0.77	2.4×10^{-7}	1.3×10^{-7}	0.00002	0.01	0.007	0.02
Total DDTs	9.1	2.8×10^{-6}	3.4×10^{-7}	0.0005	0.006	0.0007	0.007
Benzene	0.0077	2.4×10^{-9}	na ^a	0.004	0.0000006	na ^a	0.0000006
TPH-gasoline (aliphatic)	25	7.8×10^{-6}	na ^a	0.3	0.00003	na ^a	0.00003
TPH-diesel (aliphatic)	780	2.4×10^{-4}	na ^a	0.01	0.02	na ^a	0.02
Overall HI across all exposure routes/pathways^b							0.1

^a No dermal absorption factor was available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^b The overall HI is equal to the sum of HQs across multiple endpoints and/or target organs. The value indicates that the HI could not exceed 1 for individual endpoints. Therefore, HIs were not calculated for individual endpoints.

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EPC – exposure point concentration

HI – hazard index

HQ – hazard quotient

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TPH – total petroleum hydrocarbons

Table 5-18. Weighted Non-Cancer Hazard Estimates for 0 to 30-yr Exposure Duration for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Sediment

Scenario timeframe: Current/future							
Medium: Lake sediment							
Receptor population: Visitors							
Receptor age: Child and adult (aged 0 to 30)							
COPC	EPC (mg/kg dw)	Non-Cancer CDI (mg/kg-day)		Reference Dose (mg/kg-day)	Hazard Quotient		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Arsenic	6.4	2.0×10^{-6}	2.4×10^{-7}	0.0003	0.007	0.0008	0.008
Chromium	30	9.3×10^{-6}	na ^a	1.5	0.000006	na ^a	0.000006
Cobalt	14	4.3×10^{-6}	na ^a	0.0003	0.01	na ^a	0.01
Vanadium	67	2.1×10^{-5}	na ^a	0.005	0.004	na ^a	0.004
TPH-gasoline (aliphatic)	34	1.1×10^{-5}	na ^a	0.3	0.00004	na ^a	0.00004
Overall HI across all exposure routes/pathways^b							0.02

^a No dermal absorption factor was available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

^b The overall HI is equal to the sum of HQs across multiple endpoints and/or target organs. The value indicates that the HI could not exceed 1 for individual endpoints. Therefore, HIs were not calculated for individual endpoints.

CDI – chronic daily intake

HQ – hazard quotient

COPC – contaminant of potential concern

na – not applicable

dw – dry weight

RME – reasonable maximum exposure

EPC – exposure point concentration

TPH – total petroleum hydrocarbons

HI – hazard index

Table 5-19. Weighted Non-Cancer Hazard Estimates for 0 to 30-yr Exposure Duration for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Surface Water

Scenario timeframe: Current/future							
Medium: Lake surface water							
Receptor population: Visitors							
Receptor age: Child and adult (aged 0 to 30)							
COPC	EPC (mg/L)	Non-Cancer CDI (mg/kg-day)		Reference Dose (mg/kg-day)	Hazard Quotient		
		Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	Total
Arsenic (total) ^a	0.0012	2.2×10^{-7}	1.9×10^{-8}	0.0003	0.0007	0.00006	0.0008

^a Both the total and dissolved fractions were greater than the screening level. To be conservative, the total fraction was assessed in this HHRA because it was slightly higher than the dissolved fraction.

CDI – chronic daily intake

HI – hazard index

COPC – contaminant of potential concern

HQ – hazard quotient

EPC – exposure point concentration

RME – reasonable maximum exposure

HHRA – human health risk assessment

In addition to evaluating risks separately by media, the risks presented in Tables 5-11 through 5-19 can be combined based on exposure to multiple media (i.e., wetland soil, lake sediment, and lake water). Table 5-20 presents these total risk estimates.

Table 5-20. Total Risk Estimates Across Media for the Force Lake Recreational User RME Scenario

Exposure Media	Child and Adult Exposure (aged 0 to 30)	Child Exposure (aged 0 to 6)
Excess Cancer Risk		
Exposure to wetland soil	9×10^{-6}	ne ^a
Exposure to lake sediment	1×10^{-6}	ne ^a
Exposure to lake water	1×10^{-7}	ne ^a
Total risk estimate across media	1×10^{-5}	ne^a
Sum of Non-Cancer HQs		
Exposure to wetland soil	0.1	0.3
Exposure to lake sediment	0.02	0.08
Exposure to lake water	0.0008	0.002
Total risk estimate across media	0.1	0.4

^a The child age 0 to 6 excess cancer risks are not presented separately because they are lower than those for the integrated child and adult exposure.

HQ – hazard quotient

ne – not evaluated

RME – reasonable maximum exposure

As can be seen in Table 5-20, the total lifetime excess cancer risk across exposure media (1×10^{-5}) was greater than 1×10^{-6} . The overall HI was less than 1 for both age groups and for all exposure media.

Two COPCs had individual excess cancer risks greater than 1×10^{-6} : arsenic and cPAH TEQ based on exposure to wetland soil. Thus, arsenic and cPAH TEQ were identified as COCs for this scenario. No COCs were identified based on exposure to lake sediment or lake surface water.

To further evaluate the total excess cancer risk, background or reference area excess cancer risks for the Force Lake recreational user RME scenario were calculated for arsenic and cPAH TEQ because together they accounted for the majority of the total excess cancer risk (over 90%) for wetland soil and lake sediment (Table 5-21).

Table 5-21. Comparison of Study Area and Background or Reference Area Soil or Sediment Exposure Concentrations and Lifetime Excess Cancer Risk Estimates for the Force Lake Recreational User RME Scenario

Media	COPC	Soil or Sediment Exposure Concentration (mg/kg dw)		Lifetime Excess Cancer Risk	
		Study Area	Background or Reference Area ^a	Study Area	Background or Reference Area ^a
Wetland soil	Arsenic	9.6	7	2×10^{-6}	2×10^{-6}
	cPAH TEQ	1.1	0.0082 to 0.056	6×10^{-6}	4×10^{-8} to 3×10^{-7}
	Other COPCs	na	na	8×10^{-7}	ne
Lake sediment	Arsenic	6.4	7 to 7.9	1×10^{-6}	2×10^{-6}
	cPAH TEQ	0.081	0.134 to 0.149	4×10^{-7}	7×10^{-7} to 8×10^{-7}
Lake water	All COPCs	na	na	1×10^{-7}	ne
Total risk				1×10^{-5}	na

^a Background and reference area concentrations and sources are discussed in Attachment 7. Concentrations for metals are representative of background concentrations and concentrations for organic compounds are representative of reference area concentrations (i.e., concentrations in urban areas in the vicinity of the Study Area).

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

na – not applicable

ne – not evaluated

TEQ – toxic equivalent

As shown in Table 5-21, the excess cancer risk estimates for arsenic were the same for both Study Area and background concentrations (2×10^{-6}). For cPAH TEQ, the Study Area risk estimate based on exposure to wetland soil was greater than that calculated from reference area soil concentrations, while the Study Area risk estimate based on lake sediment was less than that calculated from reference area sediment concentrations.

5.3.5 Force Lake Fish Consumer

The excess cancer risk estimate for the Force Lake fish consumer scenario was greater than 1×10^{-6} for each of the three COPCs with carcinogenic effects (arsenic, total PCBs, total DDTs) (Tables 5-22 to 5-24). Thus, arsenic, total PCBs, and total DDTs were identified as COCs for this scenario. The total excess cancer risk for individuals consuming 6 meals per year of fish from Force Lake was equal to 2×10^{-5} (Table 5-22). As with the Force Lake recreational user RME scenario, HQs were calculated based on a child (0 to 6 years of age) age class and also as a weighted average over a 30-yr exposure duration (including both child and adult exposure from birth to age 30). As noted above, the integrated 0-to-30 year exposure duration HQs are presented for risk communication purposes only, and are not typically used for risk management decisions. No COPCs had HQs greater than 1 for either age

group, and no endpoint-specific HIs were greater than 1 (Tables 5-23 and 5-24).

Table 5-22. Integrated Lifetime Excess Cancer Risk Estimate for the Force Lake Fish Consumer RME Scenario

Scenario timeframe: Current/future				
Medium: Fish tissue				
Receptor population: Recreational fishermen or individuals supplementing their diets (transient individuals or individuals from ethnic populations)				
Receptor age: Child and adult (aged 0 to 30)				
COPC	EPC (mg/kg ww)^a	Cancer CDI (mg/kg-day)	Cancer Slope Factor (mg/kg-day)⁻¹	Excess Cancer Risk
Arsenic	0.22	5.0×10^{-6}	1.5	7×10^{-6}
Total PCBs	0.33	7.5×10^{-6}	2	1×10^{-5}
Total DDTs	0.30	6.8×10^{-6}	0.34	2×10^{-6}
Total excess cancer risk				2×10^{-5}

^a EPCs are estimated based on sediment concentrations and BSAFs (see Attachment 2).

BSAF – biota-sediment accumulation factor

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

EPC – exposure point concentration

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

ww – wet weight

Table 5-23. Non-Cancer Hazard Estimate for the Force Lake Fish Consumer RME Scenario Based on the Exposure of Children Aged 0 to 6 Years

Scenario timeframe: Current/future				
Medium: Fish tissue				
Receptor population: Recreational fishermen or individuals supplementing their diets (transient individuals or individuals from ethnic populations)				
Receptor age: Child (aged 0 to 6)				
COPC	EPC (mg/kg ww)^a	Non-Cancer CDI (mg/kg-day)	Reference Dose (mg/kg-day)	Hazard Quotient
Arsenic	0.22	1.7×10^{-5}	0.0003	0.06
Barium	57	4.5×10^{-3}	0.2	0.02
Cadmium	0.44	3.4×10^{-5}	0.001	0.03
Cobalt	3.9	3.1×10^{-4}	0.0003	1
Copper	22	1.7×10^{-3}	0.04	0.04
Mercury	0.021	1.6×10^{-6}	0.0001	0.02
Nickel	7.7	6.0×10^{-4}	0.02	0.03
Vanadium	19	1.5×10^{-3}	0.005	0.3
Zinc	100	7.8×10^{-3}	0.3	0.03
Total PCBs	0.33	2.6×10^{-5}	0.00002	1
Total DDTs	0.30	2.3×10^{-5}	0.0005	0.05
Hazard indices by effect:				
Hazard index for body weight endpoint (nickel)				0.03
Hazard index for cardiovascular endpoint (arsenic)				0.06
Hazard index for dermal endpoint (arsenic, vanadium)				0.4
Hazard index for developmental endpoint (mercury, PCBs)				1
Hazard index for endocrine system endpoint (nickel)				0.03
Hazard index for hematologic endpoint (cobalt, zinc)				1
Hazard index for immune system endpoint (PCBs)				1
Hazard index for kidney endpoint (barium, cadmium, nickel)				0.08
Hazard index for liver endpoint (nickel, DDTs)				0.08
Hazard index for nervous system endpoint (mercury)				0.02

^a EPCs are estimated based on sediment concentrations and BSAFs (see Attachment 2).

BSAF – biota-sediment accumulation factor

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

EPC – exposure point concentration

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

ww – wet weight

Table 5-24. Weighted Non-Cancer Hazard Estimate for 0 to 30-yr Exposure Duration for the Force Lake Fish Consumer RME Scenario

Scenario timeframe: Current/future				
Medium: Fish tissue				
Receptor population: Recreational fishermen or individuals supplementing their diets (transient individuals or individuals from ethnic populations)				
Receptor age: Child and adult (aged 0 to 30)				
COPC	EPC (mg/kg ww)^a	Non-Cancer CDI (mg/kg-day)	Reference Dose (mg/kg-day)	Hazard Quotient
Arsenic	0.22	1.2×10^{-5}	0.0003	0.04
Barium	57	3.0×10^{-3}	0.2	0.02
Cadmium	0.44	2.3×10^{-5}	0.001	0.02
Cobalt	3.9	2.1×10^{-4}	0.0003	0.7
Copper	22	1.2×10^{-3}	0.04	0.03
Mercury	0.021	1.1×10^{-6}	0.0001	0.01
Nickel	7.7	4.1×10^{-4}	0.02	0.02
Vanadium	19	1.0×10^{-3}	0.005	0.2
Zinc	100	5.3×10^{-3}	0.3	0.02
Total PCBs	0.33	1.7×10^{-5}	0.00002	0.9
Total DDTs	0.30	1.6×10^{-5}	0.0005	0.03
Hazard indices by effect:				
Hazard index for body weight endpoint (nickel)				0.02
Hazard index for cardiovascular endpoint (arsenic)				0.04
Hazard index for dermal endpoint (arsenic, vanadium)				0.2
Hazard index for developmental endpoint (mercury, PCBs)				0.9
Hazard index for endocrine system endpoint (nickel)				0.02
Hazard index for hematologic endpoint (cobalt, zinc)				0.7
Hazard index for immune system endpoint (PCBs)				0.9
Hazard index for kidney endpoint (barium, cadmium, nickel)				0.06
Hazard index for liver endpoint (nickel, DDTs)				0.05
Hazard index for nervous system endpoint (mercury)				0.01

^a EPCs are estimated based on sediment concentrations and BSAFs (see Attachment 2).

BSAF – biota-sediment accumulation factor

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

EPC – exposure point concentration

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

ww – wet weight

The majority of the total excess cancer risk based on fish consumption was attributable to total PCBs (53%), with approximately 37% attributable to arsenic, and 11% attributable to total DDTs. Endpoint-specific HIs were less than or equal to 1 for both the child exposure scenario (0 to 6 years of age) and the integrated (i.e., combined) child and adult exposure scenario (0 to 30 years of age).

To evaluate the effect of background or reference area concentrations on the risk estimates for these COPCs, background or reference area fish tissue concentrations and risks were calculated for comparison (Table 5-25).

Table 5-25. Comparison of Study Area and Background or Reference Area Exposure Concentrations and Lifetime Excess Cancer Risk Estimates for the Force Lake Fish Consumer Scenario

COPC	Exposure Concentration in Fish Tissue (mg/kg ww)		Excess Cancer Risk	
	Study Area	Background or Reference Area ^a	Study Area	Background or Reference Area ^a
Arsenic	0.22	0.24 – 0.27	7×10^{-6}	8×10^{-6} to 9×10^{-6}
Total PCBs	0.33	0.077 – 0.081	1×10^{-5}	3×10^{-6} to 4×10^{-6}
Total DDTs	0.30	0.025 – 0.030	2×10^{-6}	2×10^{-7}
Total risk			2×10^{-5}	na

^a Background and reference area concentrations and sources are discussed in Attachment 7. Concentrations for metals are representative of background concentrations and concentrations for organic compounds are representative of regional reference area concentrations (i.e., concentrations in urban areas in the vicinity of the Study Area).

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

PCB – polychlorinated biphenyl

na – not applicable

ww – wet weight

As shown in Table 5-25, the excess cancer risk estimate for arsenic based on the regional background concentration was slightly greater than the Study Area risk estimate. For both total PCBs and total DDTs, the reference area risk estimates were approximately 3 to 10 times lower than those calculated using Study Area concentrations.

In addition to the risks presented here for the Force Lake fish consumer RME scenario, cumulative risks, which account for the possibility that individuals may be exposed to lake sediment, lake water, or wetland soil while fishing at Force Lake, are presented in Section 5.5.

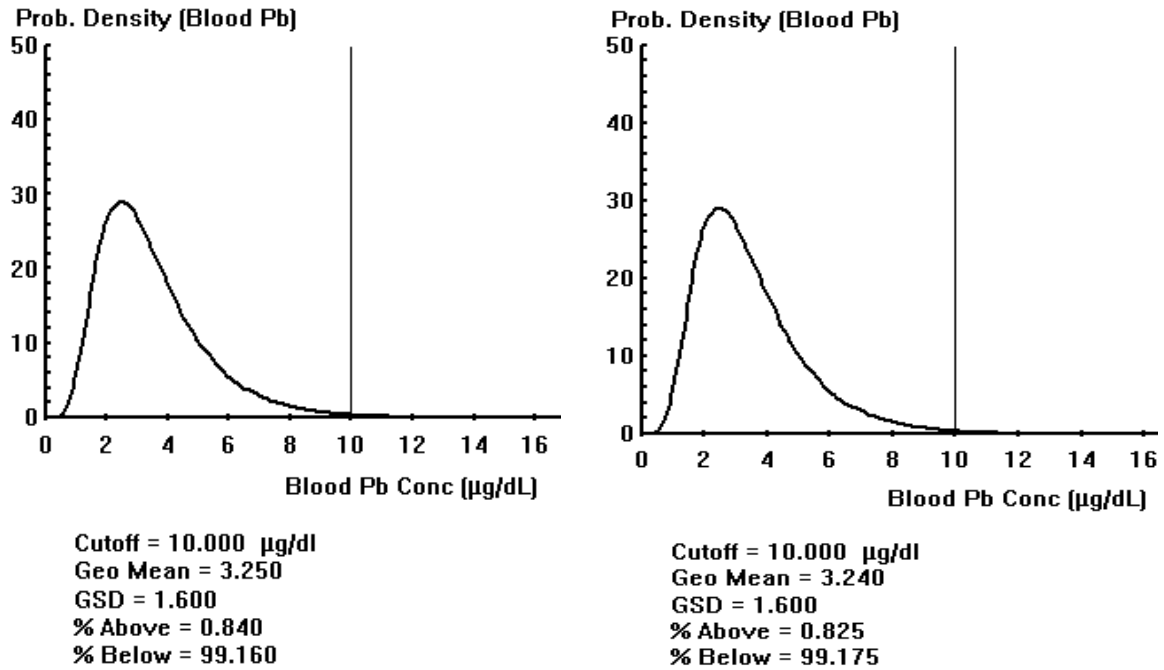
5.4 Lead Modeling Results

As described in Section 3.3.6, risks from exposure to lead were not quantified following the exposure model used for other COPCs. Because the toxicokinetics (absorption, distribution, metabolism, and excretion) of lead are well understood, health risks from lead exposure were evaluated based on blood lead concentration, which can be modeled. The results of blood lead modeling for children (IEUBK) and adults (ALM) are presented in the subsections below.

5.4.1 Children (IEUBK)

The IEUBK lead model was run using default parameters, except for the inclusion of site-specific sediment, soil, and fish tissue concentration data, as described earlier in Section 3.3.6.1. Model output is provided in the form of a probability density curve that describes the probability of blood lead concentrations occurring in a hypothetical population of children. The CDC has established a blood lead concentration of 10 µg/dL as a level of concern threshold for children above which adverse health effects may occur. The probability density curves designate the percent of children that were predicted to have blood lead levels that may exceed the threshold.

Probability density curves were generated for the Study Area using time-weighted average EPCs (Figure 5-1). For information regarding the time-weighted average approach to calculating EPC values, see Section 3.3.6.1. Note that these concentrations are less than the default soil concentration of 200 mg/kg dw in the model. However, based on this range of exposures, fewer than 0.9% of the modeled child population would have blood lead levels that exceed the CDC level of concern (shown in both graphs in Figure 5-1 as the area under the curve to the right of the vertical line, which represents 10 µg/dL). EPA's risk reduction goal for contaminated sites is that no more than 5% of the population of children exposed to lead will have blood lead levels greater than 10 µg/dL. Based on the results of the IEUBK model for the Study Area, lead was not considered to be a COC.



a) Wetland soil and fish consumption

b) Force Lake sediment and fish consumption

Figure 5-1. Probability Density Curves for Predicted Blood Lead Concentrations Using Input Data from the Children's Force Lake Recreational User RME Scenario and Force Lake Fish Consumer RME Scenario

5.4.2 Adults (ALM)

The ALM was run to estimate risks from lead exposure to the most sensitive population, which is a developing fetus. Lead risks were assessed by estimating the probability of exceeding the threshold blood lead level of 10 µg/dL in the fetus through evaluation of exposure of a pregnant mother. Results for the worker and recreational scenarios are presented in Table 5-26. As described in Section 3.3.6.2, the model was run in two modes for the Force Lake recreational user (with and without fish consumption) so that the incremental effects of fish consumption could be evaluated.

Table 5-26. Risk Estimates for Predicted Fetal and Adult Lead Levels Using the Adult Lead Model

Results	Unit	Scenario Name			
		Industrial (Construction/ Trenching) RME Worker	Future Outdoor RME Worker	Force Lake RME Recreational User	
				Wetland Soil	Force Lake Sediment
Estimates for Soil and Sediment Incidental Ingestion Only					
Predicted adult blood lead levels, CTE ^a	µg/dL	2.0	1.7	1.6	1.5
Predicted fetal blood lead levels, 95 th percentile ^b	µg/dL	6.0	5.3	4.8	4.7
Probability of fetal blood lead level exceeding 10 µg/dL (lognormal) ^c	%	1.0	0.63	0.41	0.40
Estimates Including Fish Consumption					
Predicted adult blood lead levels, CTE ^d	µg/dL	na	na	1.9	1.9
Predicted fetal blood lead levels, 95 th percentile ^b	µg/dL	na	na	5.9	5.8
Probability of fetal blood lead level exceeding 10 µg/dL (lognormal) ^c	%	na	na	0.91	0.90

^a Central tendency estimate of adult blood lead concentration for sediment intake only.

^b Estimate of 95th percentile fetal blood lead concentration.

^c Probability of exceeding EPA's threshold for fetal exposure, a blood lead level of 10 µg/dL (EPA 2003b).

^d Central tendency estimate of adult blood lead concentration for sediment ingestion and fish consumption.

CTE – central tendency estimate

EPA – US Environmental Protection Agency

na – not applicable

RME – reasonable maximum exposure

The 95th percentiles of predicted blood lead concentrations for the developing fetus were 6.0 and 5.3 µg/dL for the industrial (construction/trenching) worker RME scenario and for the future outdoor worker RME scenarios, respectively (Table 5-26). For the Force Lake

recreational user RME scenario based on exposure to either wetland soil or lake sediment, the 95th percentile of predicted blood lead concentration for the developing fetus was 4.8 µg/dL or 4.7 µg/dL, respectively, without the inclusion of fish consumption from Force Lake. The 95th percentiles of blood lead concentrations and probabilities of exceeding the 10 µg/dL threshold were slightly higher for the recreational user RME scenarios when fish consumption is included (5.9 µg/dL or 5.8 µg/dL, respectively). The probability of exceeding the 10 µg/dL blood lead threshold was less than or equal to 1.0% for all scenarios, regardless of the inclusion or exclusion of fish tissue consumption. These results indicate that lead should not be considered a COC for human health at the Study Area.

5.5 Risk Characterization Summary

This section provides a summary of excess cancer risk and non-cancer hazard estimates calculated previously in this section. Risks were evaluated for a number of different types of exposure scenarios to describe different types and intensities of site use. RME scenarios such as those evaluated in this document represent the highest exposures that are reasonably expected to occur at a site, and are generally used by EPA to evaluate remedial actions at a site (EPA 1989). In addition, it should be noted that RME, by definition, likely overestimates exposure for many individuals. The total excess cancer risks and non-cancer HQs are presented for all scenarios in Table 5-27.

Table 5-27. Summary of Total Excess Cancer Risks and Non-Cancer HQs

Scenario Name	Total Excess Cancer Risk	Overall HI ^a
Industrial (construction/trenching) worker RME scenario		
Facility soil	3×10^{-6}	1
Groundwater	8×10^{-8}	0.03
Cumulative risk across media	3×10^{-6}	1
Future outdoor worker RME scenario		
Facility soil	2×10^{-5}	0.6
Industrial/commercial worker vapor intrusion scenario		
Vapor intrusion	9×10^{-7}	ne ^b
Force Lake recreational user RME scenario		
Wetland soil	9×10^{-6}	0.3 ^c
Lake sediment	1×10^{-6}	0.08 ^c
Lake water	1×10^{-7}	0.002 ^c
Cumulative risk across media	1×10^{-5}	0.4^c
Force Lake fish consumer RME scenario		
Fish tissue consumption	2×10^{-5}	3 (endpoint-specific HIs were less than or equal to 1) ^{c, d}

^a The overall HI is equal to the sum of HQs across multiple exposure pathways, endpoints, and/or target organs.

- ^b Risks for this scenario were calculated based on a comparison Study Area concentrations with vapor intrusion screening levels, which are based on the more stringent of the cancer or non-cancer risks (i.e., whichever one results in lower screening levels). For this scenario, screening levels for all COPCs were based on cancer risks, and thus it was not possible to calculate non-cancer risks.
- ^c The overall HI is based on children 0 to 6 years of age. This HI is higher than HIs for the integrated (i.e., combined) 0-to-30-year age group and for older age groups (i.e., 7 to 16 years and 17 to 30 years), and thus is typically used for risk management decisions.
- ^d The overall HI for this scenario is equal to 3. Because this value is greater than 1, endpoint-specific HIs were calculated per EPA guidance (EPA 1989). No endpoint-specific HIs were greater than 1 (see Section 5.3.5 for details).

HI – hazard index

HQ – hazard quotient

ne – not evaluated

RME – reasonable maximum exposure

As shown in Table 5-27, the following RME scenarios had excess cancer risks greater than or equal to 1×10^{-6} and/or non-cancer HQs greater than or equal to 1:

- **Industrial (construction/trenching) worker RME scenario:** The total excess cancer risk was equal to 3×10^{-6} based on exposure to Facility soil, although no risk estimate for an individual COPC exceeded 1×10^{-6} .
- **Future outdoor worker RME scenario:** The total excess cancer risk was equal to 2×10^{-5} based on exposure to Facility soil.
- **Industrial/Commercial Worker Vapor Intrusion Scenario:** The total excess cancer risk (9×10^{-7} based on conservative published screening levels using residential exposure parameters) was less than the lower end of EPA's target risk range of 10^{-6} to 10^{-4} .
- **Force Lake recreational user RME scenario (cumulative lifetime exposure):** The total excess cancer risk was 1×10^{-5} for exposure across media, based predominantly on exposure to wetland soil (9×10^{-6}). Risks from exposure to surface water in Force Lake were less than 1×10^{-6} , indicating low risk from surface water exposure and also indicating that the concentrations in stormwater did not elevate concentrations in the lake to those that would result in risks greater than EPA's target risk range.
- **Force Lake fish consumer RME scenario (integrated lifetime exposure):** The excess cancer risk was greater than 1×10^{-6} based on the consumption of fish tissue (equal to 2×10^{-5}). No endpoint-specific HIs were greater than 1 based on either integrated lifetime exposure or on child exposure.

The excess cancer risk estimates for the scenarios listed above that were greater than 1×10^{-6} are summarized in Table 5-28. No endpoint-specific HIs were greater than 1, so for the purpose of brevity, these risks are not summarized here Table 5-28.

Table 5-28. Summary of Excess Cancer Risks for Scenarios with Total Excess Cancer Risks Greater than or Equal to 1×10^{-6}

COPC	Excess Cancer Risks (Percent of Total)				
	Industrial (Construction/ Trenching) Worker: Facility Soil	Future Outdoor Worker: Facility Soil	Force Lake Recreational User: Wetland Soil	Force Lake Recreational User: Lake Sediment	Force Lake Fish Consumer
Total Risk Estimates for Individual COPCs					
Arsenic	8×10^{-7} (31%)	7×10^{-6} (30%)	2×10^{-6} (23%)	1×10^{-6} (71%)	7×10^{-6} (37%)
cPAH TEQ	7×10^{-7} (27%)	4×10^{-6} (17%)	6×10^{-6} (68%)	4×10^{-7} (29%)	na
Total PCBs	7×10^{-7} (27%)	6×10^{-6} (26%)	3×10^{-7} (3%)	na	1×10^{-5} (53%)
Total DDTs	3×10^{-7} (12%)	2×10^{-6} (9%)	5×10^{-7} (6%)	na	2×10^{-6} (11%)
TPH-gasoline (aliphatic)	3×10^{-8} (1%)	3×10^{-6} (13%)	na	na	na
Other COPCs	5×10^{-8} (2%)	1×10^{-6} (5%)	2×10^{-10} (0%)	na	na
Total risk	3×10^{-6}	2×10^{-5}	9×10^{-6}	1×10^{-6}	2×10^{-5}
Background or Reference Area Risk Estimates^a					
Arsenic	6×10^{-7}	4×10^{-6}	2×10^{-6}	2×10^{-6}	8×10^{-6} to 9×10^{-6}
cPAH TEQ	6×10^{-9} to 4×10^{-8}	3×10^{-8} to 2×10^{-7}	4×10^{-8} to 3×10^{-7}	7×10^{-7} to 8×10^{-7}	na
Total PCBs	5×10^{-9}	2×10^{-8}	nc	na	3×10^{-6} to 4×10^{-6}
Total DDTs	nc	2×10^{-9} to 5×10^{-8}	nc	na	2×10^{-7}

^a Background and reference area concentrations and sources are discussed in Attachment 7. Concentrations for metals are representative of background concentrations and concentrations for organic compounds are representative of regional reference area concentrations (i.e., concentrations in urban areas within the vicinity of the Study Area). No background or reference area concentrations were available for TPH-gasoline (aliphatic).

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

na – not applicable

nc – not calculated

PCB – polychlorinated biphenyl

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

As shown in Table 5-28, arsenic, cPAHs, total PCBs, total DDTs, and TPH-gasoline (aliphatic) accounted for nearly all of the risk across scenarios.

For both worker RME scenarios, the majority (over 70%) of the total excess cancer risk was attributable to arsenic, cPAH TEQ, and total PCBs, with a lesser contribution from total DDTs and TPH-gasoline (aliphatic). However, for both worker scenarios, risk estimates calculated based on the DEQ background concentration for arsenic were comparable to (although somewhat less than) those based on Study Area concentrations, indicating that the regional background concentration for arsenic is an important consideration when evaluating the Study Area risk estimate. Risk estimates based on reference area soil concentrations for cPAH TEQ, total PCBs, and total DDTs were less than Study Area risk estimates.

For the Force Lake recreational user RME scenario, the majority (over 90%) of the total excess cancer risk (equal to 9×10^{-6} for exposure to wetland soil and equal to 1×10^{-6} for exposure to lake sediment) was attributable to arsenic and cPAH TEQ. However, risks calculated based on background concentrations for arsenic were similar to (wetland soil) or higher than (lake sediment) risk estimates based on Study Area concentrations. Reference area risk estimates for cPAH TEQ were less than Study Area risk estimates for scenarios based on exposure to soil but were less for scenarios based on exposure to sediment.

For the Force Lake fish consumer RME scenario, the majority of the risk was attributable to total PCBs (53%), with lower percentages attributable to arsenic (37%) and total DDTs (11%). Risks calculated based on background concentrations for arsenic were higher than those based on Study Area concentrations and the Study Area risk estimate for total DDTs was within the range of risks calculated using reference area fish tissue concentrations. No endpoint-specific HIs were greater than 1 for any scenario.

In addition, per EPA guidance (EPA 1989), risks for multiple scenarios were summed to represent possible cumulative risk for individuals who engage in several different activities. For this HHRA, it is possible for individuals fishing at Force Lake to also be exposed to wetland soil, lake sediment, and lake water (i.e., the Force Lake recreational user). The sum of the excess cancer risks for the Force Lake recreational user and the Force Lake fish consumer is presented in Table 5-29 for both adults and children. No other multiple scenario combinations are expected for the Study Area.

Table 5-29. Excess Cancer Risk Estimates Across Scenarios

Scenario	Cumulative Lifetime Excess Cancer Risk ^a
Force Lake recreational user RME scenario	
Exposure to wetland soil	9×10^{-6}
Exposure to lake sediment	1×10^{-6}
Exposure to lake water	1×10^{-7}
Force Lake fish consumer RME scenario	
Exposure via fish consumption	2×10^{-5}
Cumulative risk across scenarios	3×10^{-5}

^a Cumulative lifetime excess cancer risks were calculated for the total exposure duration of 30 years, ranging from birth to age 30 to include the most sensitive life stage.

As shown in Table 5-29, the cumulative risk based on the Force Lake recreational user RME scenario and the Force Lake fish consumer RME scenario was based largely on the risks associated with the consumption of fish from Force Lake (approximately 67% of the total). This analysis demonstrates that direct exposure to wetland soil, lake sediment, and lake surface water contributed relatively little to recreational risk estimates when both direct exposure and fish consumption were assessed.

6.0 UNCERTAINTY ANALYSIS

In any risk assessment, there is always some uncertainty regarding the resulting risk estimates. Despite using the best available information to parameterize the scenarios evaluated in this baseline HHRA and to represent the toxicity of the COPCs, these estimates are inherently uncertain. Table 6-1 presents a summary of the uncertainties inherent in the risk estimates presented in this document.

Table 6-1 Summary of Uncertainties Identified in the Baseline HHRA

Parameter	Level of Uncertainty	Effect of Uncertainty on Risk Estimate	Potential Means to Reduce Uncertainty	Potential Impact on Risk Estimates	Comments
Exposure assessment					
EPCs for small datasets or infrequently detected COPCs (Section 6.1.1)	low to medium	For COPCs where fewer than six detected concentrations were available, the higher of either the maximum detect or half the maximum RL was used as the EPC. This value may under- or over-estimate the true mean.	Collect additional data with lower reporting limits	low	The majority of datasets (including all COCs) had 6 or more detected values and thus it was possible to calculate a UCL. All COCs had 6 or more detects, and thus UCLs could be calculated.
COPCs lacking guidance on dermal absorption fractions (Section 6.1.2)	medium	The underestimation of dermal risks from metals lacking absorption factors is expected to have small effect on overall risk estimates.	Evaluate risks based on a range of absorption assumptions	low	Dermal absorption is dependent on the speciation of metals, but is typically low. Risk calculations in this uncertainty assessment were done assuming that dermal absorption ranged from 0.001 to 0.03 (the range of available for metals). These risk estimates indicate this pathway likely does not contribute significantly to underestimation.
Exposure frequency for the Force Lake recreational user scenario (Section 6.1.3)	medium	Total risk estimates may be overestimated.	Further evaluation of recreational activities at the Study Area	low	The exposure frequency used for the Force Lake recreational user was likely overestimated given the conditions at the Study Area. This, risks to recreational users are likely to be lower than those presented in Section 5.
Use of BSAFs to estimate fish tissue concentrations (Section 6.1.4)	high	Total risk estimate may be over- or underestimated, although overestimation is more likely.	Collect fish tissue from Force Lake	medium to low	Based on the analysis performed in Section 6.1.3, uncertainty in the BSAF value can increase or decrease risk estimates. The total excess cancer risk is unlikely to increase significantly if fish tissue was collected, but could decrease.

Table 6-1 Summary of Uncertainties Identified in the Baseline HHRA

Parameter	Level of Uncertainty	Effect of Uncertainty on Risk Estimate	Potential Means to Reduce Uncertainty	Potential Impact on Risk Estimates	Comments
Fish consumption rate (Section 6.1.5)	high	May over- or underestimate the risks associated with the consumption of fish tissue.	Conduct a creel study or formal fishing survey	unknown	Risk estimates have a one-to-one relationship with consumption rates, and thus are sensitive to changes in this value. However, based on the number of fish present in Force Lake, a consumption rate higher than six meals per year is unlikely, as discussed in Section 6.1.4.
Toxicity Assessment					
Chemicals without RSLs (Section 6.2.1)	low	Total risk estimate may be somewhat underestimated.	Develop RSLs and/or toxicity values for these COPCs	low	Chemicals without RSLs are listed in Section 6.2.1.
COPCs without toxicity values (Section 6.2.2)	low	total risk estimate may be somewhat underestimated.	Develop toxicity values for these COPCs	low	The few COPCs without toxicity values for a given pathway are listed in Section 6.2.2.
Risk Characterization					
Risks from non-detected COPCs (Section 6.3.1)	low	May have no effect, or may mean that risks estimates are underestimated if COPC is present.	Achieve lower reporting limits	low for total risk estimates	Reporting limits for non-detected COPC are compared to RSLs in Section 6.3.1.
Risks to current Facility workers from soil berm and soil stockpile (Section 6.3.2)	low	Likely has no effect because of the low exposure potential of current outdoor workers to this soil	Interview workers	low for total risk estimates	The soil berm and soil stockpile are both located in areas away from the everyday activities of workers at the Facility, and thus risk from the exposure to this soil is low.

BSAF – biota sediment accumulation factor

EPC – exposure point concentration

HHRA – human health risk assessment

RSL – regional screening level

The following subsections further discuss the uncertainties summarized in Table 6-1, divided into sections on the exposure assessment, toxicity assessment, and risk characterization.

6.1 Exposure Assessment

For most HHRA, including this assessment of risks to people at the Study Area, assumptions made during the exposure assessment contribute a high level of uncertainty and variability to the risk estimates. Alternative exposure values are possible for the parameters described in Section 3.0, which would in turn affect the risk estimates presented in Section 5.0.

This section addresses uncertainties related to the exposure assessment, including exposure point concentrations, dermal absorption factors, BSAFs used to calculate fish tissue concentrations, and the fish consumption rate used in the HHRA.

6.1.1 Exposure Point Concentrations

For all COPCs, ProUCL 4.00.04 software was used to develop UCLs on the mean. This software first evaluates the distribution of the data, then recommends a statistical approach and provides an estimated UCL (EPA 2009d). The UCLs were intended to provide reasonably health-protective estimates of the EPCs for the infrequently detected COPCs present in soil, sediment, and water at the Study Area. However, when fewer than six detected concentrations were available for a given dataset, the higher of either the maximum detect or half of the maximum RL was used as the EPC. The following subsections address cases when ProUCL could not be used to calculate a UCL.

6.1.1.1 EPC Estimates for Small Datasets

This section discusses the uncertainties associated with datasets with fewer than six samples. As described above, a UCL was not calculated for datasets with fewer than six samples. For datasets with fewer than six samples, the higher of either the maximum detected concentration or half the maximum RL was used as the EPC. The uncertainty related to potential EPC under- or over-estimation is greater for EPCs derived for small datasets with fewer than six samples because it was not possible to use ProUCL.

For this HHRA, less than 10% of the EPCs had fewer than 6 samples in the dataset, none of which were for COCs. Thus, the uncertainty related to the calculation of EPCs for small samples sizes is low.

6.1.1.2 EPC Estimates for Infrequently Detected COPCs

ProUCL 4.00.04 was used to calculate a UCL when there were six or more detected values because it provides defensible statistical methods for UCL calculations, and does not rely on simple substitutions for the non-detected data points. ProUCL software allows for parametric and non-parametric analysis of both uncensored datasets (i.e., all detected concentrations) and those that contain non-detects to determine a distribution from which a UCL may be calculated. Some of the statistical methods (e.g., Kaplan-Meier method) are able to handle datasets that have multiple detection levels (EPA 2009d). These more accurate methods for identifying distributions make it possible to better define the appropriate UCL value for use in risk assessment.

Approximately 35% of the datasets for which EPCs were needed had detection frequencies of less than 50%. For those datasets where more than six detected values were available, ProUCL was used to calculate a UCL, thus reducing some of the uncertainty associated with the low detection frequency. However, approximately half of these datasets also had less than six detected values, and thus ProUCL could not be used. For these datasets, the higher of either the maximum detect or half of the maximum RL was used as the EPC. While the use of the maximum value here may under- or overestimate the EPC, the low number of EPCs that are maximum values helps to reduce this uncertainty. Additionally, none of the COPCs that fall into this category were identified as COCs.

6.1.2 Dermal Absorption Fractions

Dermal exposure to nine metals identified as COPCs for the direct sediment exposure scenarios was not evaluated because these COPCs lacked dermal absorption factors. EPA guidance states that “for inorganics, the speciation of the compound is critical to the dermal absorption and there are too little data to extrapolate a reasonable default value” (EPA 2004). Therefore, only incidental ingestion and/or inhalation for these 9 COPCs was considered in the risk characterization. Note that dermal exposure was not evaluated for an additional 14 VOCs because, as stated in EPA guidance (2004), no default dermal absorption values are available for VOCs because they “would tend to be volatilized from the soil on skin and should be accounted for via inhalation routes in combined exposure pathways.”

Although it is not possible to estimate the dermal absorption for the nine metals, a sensitivity analysis was conducted to evaluate the importance of the dermal portion of the total risk estimate (i.e., whether risks were likely to be significantly underestimated because of the absence of dermal absorption calculations). For metals, DEQ (1998) has recommended a default dermal absorption value of 0.01 (EPA 1995). For this exercise, dermal absorption fractions that were an order of magnitude on either side of this default value were evaluated. Alternate risk estimates using these default dermal absorption values were calculated. No additional excess cancer risk exceedances of 1×10^{-6} or HQ exceedances of 1 occurred for any scenario.

In addition, risks were calculated for one metal assuming several different absorption factors to assess the impacts on risk estimates of different assumptions for dermal absorption values. Cobalt was selected because of its higher toxicity relative to other metals and the higher risks estimated using default dermal absorption values. Therefore, the inclusion of dermal exposure would be expected to have a more significant impact on risk estimates than the inclusion of dermal exposure for other metals without ABS.

Table 6-2 presents non-cancer risk estimates for cobalt using a range of dermal absorption values for several scenarios.

Table 6-2. Risk Estimates Using a Range of Dermal Absorption Values for Cobalt

Dermal Absorption Factor ^a	Hazard Quotient			
	Incidental Ingestion	Dermal Absorption	Inhalation	Total
Industrial (Construction/Trenching) Worker RME Scenario: Facility Soil				
0.1	0.1	0.1	0.00009	0.2
0.01	0.1	0.01	0.00009	0.1
0.001	0.1	0.001	0.00009	0.1
none	0.1	none	0.00009	0.1
Future Outdoor Worker RME Scenario: Facility Soil				
0.1	0.05	0.02	0.0004	0.07
0.01	0.05	0.002	0.0004	0.05
0.001	0.05	0.0002	0.0004	0.05
none	0.05	none	0.0004	0.05
Force Lake Recreational User RME Scenario: Exposure of Children Aged 0 to 6 to Wetland Soil^b				
0.1	0.04	0.007	na	0.05
0.01	0.04	0.0007	na	0.04
0.001	0.04	0.00007	na	0.04
none	0.04	none	na	0.04
Force Lake Recreational User RME Scenario: Exposure of Children Aged 0 to 6 to Lake Sediment^b				
0.1	0.04	0.008	na	0.05
0.01	0.04	0.0008	na	0.04
0.001	0.04	0.00008	na	0.04
none	0.04	none	na	0.04

Note – The incidental ingestion and inhalation HQs were presented in the risks characterization (Section 5.3) and are presented here for completeness.

^a EPA guidance provides a dermal absorption value for only two metals (0.03 for arsenic and 0.001 for cadmium). The hypothetical range of dermal absorption factors included in this table (0.1, 0.01, and 0.001) is inclusive of the values available for these metals.

^b Risks to children aged 0 to 6 presented in Section 5.3 were higher than or equal to those for cumulated lifetime exposure, and thus the Force Lake recreational user scenario based on the exposure of children aged 0 to 6 is shown here.

EPA – US Environmental Protection Agency

na – not applicable or available
RME – reasonable maximum exposure

As can be seen in Table 6-2, the HQs for cobalt change only slightly (if at all) across the range of ABS used. Thus, it can be concluded that the lack of dermal absorption factors for metals (and the absence of significant risks based on dermal exposure for these COPCs) is unlikely to affect overall conclusions from this HHRA.

6.1.3 Force Lake Recreational User Exposure Frequency

The exposure frequency (22 days per year) used to evaluate risks to individuals exposed to wetland soil, Force Lake sediment, and Force Lake surface water was based on the assumption that individuals visit the Study Area once per week during the summer (13 weeks) and once per month during the rest of the year (9 months). However, given the conditions at the Study Area (i.e., limited public access and lack of recreational facilities), the exposure frequency is likely to be less than the 22 days per year assumed in this HHRA. Thus, risks would be expected to be lower than those presented in Section 5. Exposure frequency represents a relatively low source of uncertainty for this HHRA because risks from sediment and soil were relatively low (i.e., equal to 1×10^{-6} to 9×10^{-6}).

6.1.4 Calculation of Contaminant Concentrations in Fish Tissue Using BSAFs

Fish tissue samples were not analyzed for contaminant concentrations in Force Lake because of the low level of concentrations found in Force Lake sediments. Thus, to evaluate the risks to humans from the consumption of fish, contaminant concentrations in fish tissue were estimated using BSAFs (see Attachment 2). As discussed in Section 5.0, arsenic, total PCBs and total DDTs were the main COPCs contributing to the total excess cancer risk exceeding 1×10^{-6} . No COPCs had an HQ greater than 1. This section discusses the BSAFs for arsenic, total PCBs, and total DDTs in more detail. Table 6-3 presents the BSAFs used in the HHRA along with a discussion of the selected values used in this HHRA.

Table 6-3. Fish BSAFs Used in the HHRA

COPC	BSAF	Source	Discussion of Selected Value
Arsenic	0.12 dw/dw	PTI (1995b)	Only one fish BSAF value (0.12) was presented in the PTI report for arsenic (1995b). The average invertebrate BSAF from this source was 0.12, with a range of BSAFs from 0.022 to 0.71.
Total PCBs	6.45 lipid/OC	mean of BSAFs in EPA database (2008a) ^a	The dataset contains 285 BSAFs, ranging from 0.0038 to 258, with a median value of 2.07 and a mean value of 6.45. The standard deviation is 21 and the standard error is 1.2.

Table 6-3. Fish BSAFs Used in the HHRA

COPC	BSAF	Source	Discussion of Selected Value
Total DDTs	3.01 lipid/OC	weighted average of the mean BSAFs for components detected in Force Lake (16% 2,4'-DDD, 29% 4,4'-DDD, and 55% 4,4'-DDE)	2,4'-DDD: A geometric mean of 0.045 was selected from PTI (1995a). The range of BSAFs reported was 0.006 to 0.12, with a median of 0.084.
			4,4'-DDD: A mean BSAF of 0.83 was calculated from EPA's BSAF database (2008a). The dataset contains 28 BSAFs, ranging from 0.10 to 2.23, with a median value of 0.74. The standard deviation is 0.61 and the standard error is 0.12.
			4,4'-DDE: A mean BSAF of 5.00 was calculated from EPA's BSAF database (2008a). The dataset contains 34 BSAFs, ranging from 0.070 to 35, with a median value of 1.2. The standard deviation is 7.9 and the standard error is 1.3.

^a BSAF is the average BSAF reported in EPA's BSAF database for all fish species.
 BSAF – biota sediment accumulation factor EPA – US Environmental Protection Agency
 DDE – dichlorodiphenyldichloroethylene HHRA – human health risk assessment
 DDT – dichlorodiphenyltrichloroethane OC – organic carbon
 dw – dry weight PCB – polychlorinated biphenyl

As can be seen in Table 6-3, considerable variability exists regarding available BSAF values. The minimum to maximum range of BSAFs can span several orders of magnitude (although often because of the presence of outliers in the dataset). Table 6-4 presents excess cancer risks for the Force Lake fish consumer RME scenarios for a range of BSAFs to determine the impact of BSAF uncertainty on risk estimates.

Table 6-4. Risk Calculations Across a Range of BSAFs

Description of BSAF Value	BSAF Value	Lifetime Excess Cancer Risks
Arsenic		
Selected value for HHRA	0.12 dw/dw	7×10^{-6}
Median value for invertebrates ^a	0.064 dw/dw	4×10^{-6}
10 th Percentile for invertebrates ^a	0.045 dw/dw	2×10^{-6}
90 th Percentile for invertebrates ^a	0.41 dw/dw	2×10^{-5}
Total PCBs		
Selected value for HHRA	6.45 lipid/OC	1×10^{-5}
Median BSAF	2.07 lipid/OC	4×10^{-6}
10 th Percentile of BSAFs	0.17 lipid/OC	4×10^{-7}
90 th Percentile of BSAFs	12.6 lipid/OC	3×10^{-5}
Total DDTs		
Selected value for HHRA	3.01 lipid/OC	2×10^{-6}
Median BSAF	0.89 lipid/OC	7×10^{-7}
10 th Percentile of BSAFs ^b	0.10 lipid/OC	8×10^{-8}
90 th Percentile of BSAFs ^b	11.5 lipid/OC	9×10^{-6}

Table 6-4. Risk Calculations Across a Range of BSAFs

Description of BSAF Value	BSAF Value	Lifetime Excess Cancer Risks
Total Excess Cancer Risk		
Selected value for HHRA	na	2×10^{-5}
Median BSAF	na	8×10^{-6}
10 th Percentile of BSAFs	na	2×10^{-6}
90 th Percentile of BSAFs	na	6×10^{-5}

^a As discussed in Table 6-3, only one fish BSAF was available for arsenic. Invertebrate BSAFs were used in this table to provide a range of possible BSAFs.

^b No 10th and 90th percentiles could be calculated for 2,4'-DDD because only summary statistics were presented by PTI (1995a). Thus, the minimum and maximum values were used to calculate the total DDT BSAF for 2,4'-DDD.

BSAF – biota sediment accumulation factor OC – organic carbon
 DDT – dichlorodiphenyltrichloroethane PCB – polychlorinated biphenyl
 HHRA – human health risk assessment

As can be seen in Table 6-4, excess cancer risk estimates changed significantly compared to the original risk estimates when the high-end (maximum or 90th percentile) and low-end (minimum or 10th percentile) BSAFs were used.

Based on this assessment, the use of BSAFs (rather than actual fish tissue data) to estimate fish tissue concentrations is unlikely to result in a significant underestimation of the total excess cancer risk. Because conservative (i.e., health protective) BSAFs were used, the total excess cancer risk is more likely to be overestimated.

6.1.5 Fish Consumption Rate

In order to characterize risks to people based on the consumption of fish from Force Lake, it was necessary to estimate the number of meals of fish consumed by people who fish at the lake (see Section 3.3.3). Based on the available information, a rate of six meals per year was selected to conservatively represent various types of individuals who may fish at Force Lake, including recreational anglers, ethnic populations using fish collected from Force Lake to supplement their diet, or transient individuals collecting fish from Force Lake as they move around the area. However, because of the lack of creel studies or formal fishing surveys regarding fish consumption for Force Lake, the consumption rate used in this HHRA is uncertain. This section discusses this source of uncertainty in relation to the total excess cancer risk of 2×10^{-5} estimated in Section 5.3.

Because the consumption rate has a one-to-one relationship with the estimated risk based on fish consumption, the risk estimate is highly sensitive to consumption rate assumptions. Alternate excess cancer risk estimates were calculated for a range of consumption rates for the adult Force Lake fish consumer scenario because risks to adults were higher than those to children. The following three rates are discussed in this section:

- **3 meals per year (1.88 g/day):** Half of the selected fish consumption rate for the Study Area. This rate may be more realistic based on the results of the 2009 and late 1980s fish surveys (see Section 3.3.3).
- **6 meals per year (3.75 g/day):** The selected fish consumption rate for the Study Area.
- **28 meals per year (17.5 g/day):** The current EPA default fish consumption rate for the protection of water quality (EPA 2000b).

Table 6-5 presents the risk estimates associated with these consumption rates. In addition, these fish consumption rates are shown in Figure 6-1, which illustrates the relationship between the fish consumption rate and the excess cancer risk.

Table 6-5. Risk Estimates Across Fish Consumption Rates

Consumption Rate	Meals per Year	Lifetime Excess Cancer Risk
Half of the Harbor Oil fish consumption rate	3	1×10^{-5}
Harbor Oil HHRA consumption rate	6	2×10^{-5}
DEQ default fish consumption rate	28	1×10^{-4}

DEQ – Oregon Department of Environmental Quality

HHRA – human health risk assessment

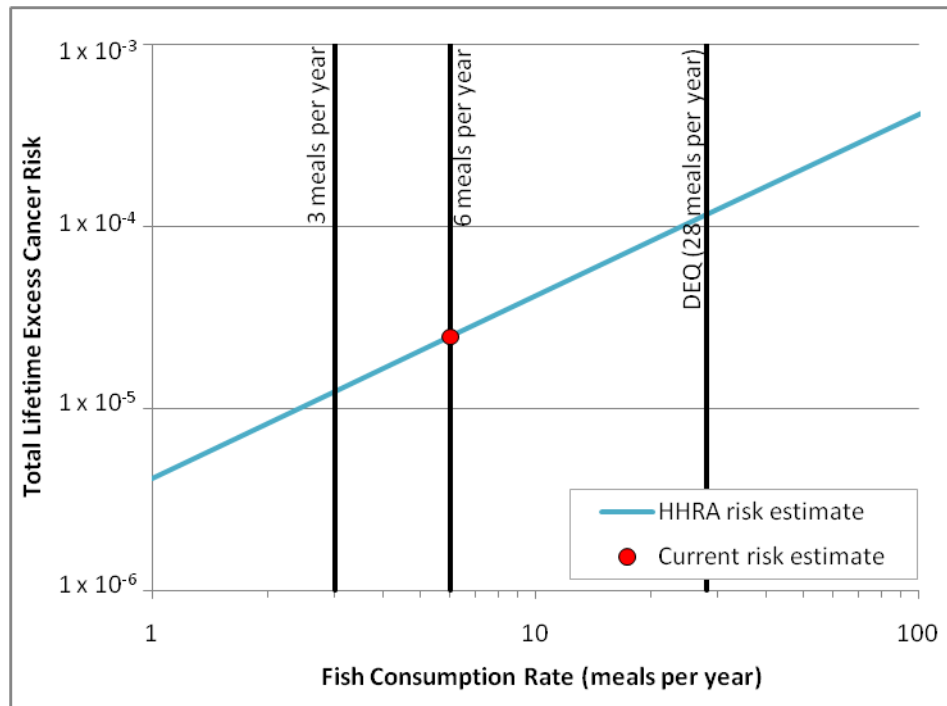


Figure 6-1. Excess Cancer Risk Estimates across Fish Consumption Rates

As can be seen in Figure 6-1, the selection of a consumption rate is important in the estimation of risks to people from the consumption of fish from Force Lake. At the selected rate of six meals per year, the integrated lifetime excess cancer risk was 2×10^{-5} . A decrease in the fish consumption rate to three meals per year (half of the rate used in this HHRA) would have resulted in an integrated lifetime excess cancer risk of 1×10^{-5} . An increase in the fish consumption rate to the EPA default rate of 28 meals per year would have resulted in an integrated lifetime excess cancer risk of 1×10^{-4} .

To estimate the feasibility of various fish consumption rates, the number of fish collected during the 2009 Force Lake fish survey was compared to the number of fish that would be needed to support six anglers at each of these rates (Table 6-6). This comparison was done assuming only adult anglers and assuming each adult angler was also feeding one young child (aged 0 to 6).

Table 6-6. Number of Fish Needed for Six Anglers Consuming Fish from Force Lake Under Various Consumption Rate Scenarios

Fish Size Category	Fish Collected During the 2009 Survey ^a	Number of Fish Needed per Year to Support Various Consumption Rates for Six Anglers		
		Half of the Harbor Oil Fish CR (3 meals per year)	Harbor Oil HHRA CR (6 meals per year)	EPA Default Fish CR (28 meals per year)
Adults Only				
Small fish (less than 15 cm in length)	76	180 – 270	360 – 540	1,680 – 2,520
Medium-sized fish (15 to 25 cm in length)	12	36 – 54	72 – 108	336 – 504
Large fish (over 50 cm in length)	1 – 2 ^b	18	36	168
Adults and Children				
Small fish (less than 15 cm in length)	76	230 – 346	461 – 691	2,150 – 3,226
Medium-sized fish (15 to 25 cm in length)	12	46 – 69	92 – 138	430 – 645
Large fish (over 50 cm in length)	1 – 2 ^b	23	46	215

Note: One adult meal (8 oz or 228 g) was assumed to be equal to either 1 large fish (over 50 cm in length), 2 to 3 medium-sized fish (15 to 25 cm in length), or 10 to 15 small fish (less than 15 cm in length). The number of fish per adult meal was scaled based on the young child meal size of 64 g (for children aged 0 to 6).

^a Source: Windward (2009b)

^b The large fish (carp) were observed during the fish survey but were not captured.

CR – consumption rate

EPA – US Environmental Protection Agency

HHRA – human health risk assessment

As can be seen in Table 6-6, the population of fish in the lake is small, particularly when compared to the numbers of fish that would be needed to support fishing at the default EPA consumption rate of 28 meals per year and even compared to the rate proposed corresponding to consumption of six meals per year. Given the survey methods that were used and conditions under which the survey was conducted, it is unlikely that Force Lake contains the numbers of fish needed to support six anglers at the EPA default consumption rate, which would require that each year anglers catch several hundred more fish than were observed during the 2009 survey. As can be seen from Table 6-6, it is even unlikely that the lake would support the consumption rate of six meals per year assumed for the HHRA.

6.2 Toxicity Assessment

This section addresses uncertainties related to the toxicity assessment of chemicals for the Study Area, including chemicals without RSLs (Section 6.3.1) and COPCs without toxicity information (Section 6.2.2).

6.2.1 Chemicals without RSLs

The toxicity benchmarks used in this baseline HHRA are based on the most recent guidance provided by EPA (see Section 3.2). They are health-protective in that they include uncertainty factors or extrapolations to account for sensitive sub-populations or other limitations of the toxicity data on which they are based. However, for some chemicals, no screening levels (e.g., RSLs) are available. Table 6-7 presents a list of those chemicals without soil or sediment RSLs, Table 6-8 presents a list of those chemicals without water RSLs, and Table 6-9 presents a list of those chemicals without fish RSLs. More information on the results of the analysis of these chemicals is available in Attachment 3.

Table 6-7. Chemicals Without Soil RSLs

Detected Chemicals	Non-Detected Chemicals
Metals Calcium Manganese Sodium Other SVOCs Carbazole PAHs Benzo(g,h,i)perylene Dibenzofuran Phenanthrene VOCs Methyl ethyl ketone Methyl isobutyl ketone Methylcyclohexane n-Butylbenzene	Other SVOCs 2-Nitrophenol 3-Nitroaniline 4-Bromophenyl phenyl ether 4-Chloro-3-methylphenol 4-Chlorophenyl phenyl ether 4-Nitrophenol Phthalates Dimethyl phthalate Di-n-octyl phthalate VOCs 1,1-Dichloropropene 1,2,3-Trichlorobenzene 2,2-Dichloropropane 2-Hexanone

Table 6-7. Chemicals Without Soil RSLs

Detected Chemicals	Non-Detected Chemicals
p-Cymene tert-Butylbenzene	Bromochloromethane

Note: No sediment RSLs are available, and thus soil RSLs were used in this risk assessment, as discussed in Section 3.2.1.

PAH – polycyclic aromatic hydrocarbon

SVOC – semivolatile organic compound

RSL – regional screening level

VOC – volatile organic compound

Table 6-8. Chemicals Without Water RSLs

Detected Chemicals	Non-Detected Chemicals	
Metals Aluminum Antimony Cadmium Calcium Cobalt Iron Magnesium Potassium Selenium Sodium Thallium Vanadium Zinc Other SVOCs 2-Chlorophenol Acetophenone Benzaldehyde Phenol PAHs 2-Methylnaphthalene Dibenzofuran Phenanthrene Phthalates Di-n-butyl phthalate Diethyl phthalate VOCs Acetone n-Butylbenzene p-Cymene	Other SVOCs 1,2,4-Trichlorobenzene 2,4,5-Trichlorophenol 2,4-Dichlorophenol 2,4-Dimethylphenol 2,4-Dinitrophenol 2,4-Dinitrotoluene 2-Methylphenol 2-Nitroaniline 2-Nitrophenol 3-Nitroaniline 4,6-Dinitro-o-cresol 4-Bromophenyl phenyl ether 4-Chloro-3-methylphenol 4-Chloroaniline 4-Chlorophenyl phenyl ether 4-Methylphenol 4-Nitroaniline 4-Nitrophenol Atrazine Biphenyl bis(2-chloroethoxy)methane bis(2-chloroethyl)ether bis(2-chloroisopropyl)ether Caprolactam Carbazole Hexachlorobutadiene Hexachlorocyclopentadiene Isophorone Nitrobenzene N-Nitroso-di-n-propylamine N-Nitrosodiphenylamine Hexachlorobutadiene PAHs 2-Chloronaphthalene Benzo(g,h,i)perylene	Pesticides beta-BHC delta-BHC gamma-Chlordane Methoxychlor beta-BHC delta-BHC gamma-Chlordane Methoxychlor Phthalates Butyl benzyl phthalate Dimethyl phthalate Di-n-octyl phthalate VOCs 1,1,1,2-Tetrachloroethane 1,1,2,2-Tetrachloroethane 1,1,2-Trichlorotrifluoroethane 1,1-Dichloropropene 1,2,3-Trichlorobenzene 1,2,3-Trichloropropane 1,2-Dibromo-3-chloropropane 1,2-Dichloropropane 1,3-Dichloropropane 2,2-Dichloropropane 2-Chlorotoluene 2-Hexanone 4-Chlorotoluene Bromobenzene Bromochloromethane Carbon disulfide cis-1,3-Dichloropropene Cyclohexane Dibromochloromethane Dibromomethane Dichlorodifluoromethane Methyl acetate Methyl ethyl ketone Methyl isobutyl ketone Methylcyclohexane tert-Butylbenzene Tetrachloroethene trans-1,3-Dichloropropene Vinyl acetate 1,2-Dichloroethene

BHC – benzene hexachloride

PAH – polycyclic aromatic hydrocarbon

RSL – regional screening level

SVOC – semivolatile organic compound

VOC – volatile organic compound

Table 6-9. Chemicals Without Fish RSLs

Detected Chemicals	Non-Detected Chemicals
PAHs Benzo(g,h,i)perylene Dibenzofuran Phenanthrene	Other SVOCs 1,3-Dichlorobenzene Pesticides delta-BHC VOCs 1,1,2-Trichlorotrifluoroethane 1,1-Dichloroethene 1,1-Dichloropropene 1,2,3-Trichlorobenzene 1,2,4-Trimethylbenzene 1,2-Dibromoethane (EDB) 2,2-Dichloropropane 2-Chlorotoluene 2-Hexanone 4-Chlorotoluene Bromochloromethane Chloroethane Chloromethane cis-1,2-Dichloroethene cis-1,3-Dichloropropene p-Cymene Dibromomethane Dichloromethane Isopropylbenzene Methyl isobutyl ketone n-Butylbenzene n-Propylbenzene sec-Butylbenzene tert-Butyl methyl ether tert-Butylbenzene Tetrachloroethene trans-1,2-Dichloroethene trans-1,3-Dichloropropene

EDB – ethylene dibromide

BHC – benzene hexachloride

PAH – polycyclic aromatic hydrocarbon

RSL – regional screening level

SVOC – semivolatile organic compound

VOC – volatile organic compound

Toxicity information for these chemicals is not provided in the EPA, DEQ, EPA AWQC, or EPA Region 3 sources identified for use in this HHRA (see Section 3.2). Because these chemicals were not identified as COPCs through screening, they were not included in risk estimates. Overall risks may have been underestimated if there are significant toxic effects associated with these chemicals. However, the fact that toxicity values have not been developed for these chemicals provides some indication that the toxicity of these chemicals is generally lower than that

of chemicals for which toxicity values have been developed because scientists conducting toxicity studies tend to prioritize chemicals suspected to be the most toxic.

6.2.2 COPCs without Toxicity Values

Four types of toxicity values were used in this HHRA, including two non-cancer toxicity values (an oral RfD and an inhalation RfC) and two carcinogenic toxicity values¹⁵ (an oral cancer SF and an inhalation unit risk factor). For each of these types of toxicity values, it was not possible to find a value for several COPCs:

- COPCs lacking a oral/dermal RfD: cPAH TEQ, tert-butyl methyl ether, and trichloroethene
- COPCs lacking an inhalation RfC: copper, cPAH TEQ, total DDTs, dichloromethane, and trichloroethene
- COPCs lacking an oral/dermal cancer SF: cobalt, mercury and naphthalene, TPH-gasoline (aliphatic), TPH-diesel (aliphatic)
- COPCs lacking an inhalation unit risk factor: naphthalene

As can be seen from this list, there were relatively few COPC-toxicity value combinations where a value could not be determined, indicating that the level of uncertainty associated with the lack of toxicity values is low. In addition, it should be noted that there was at least one toxicity value available for each COPC. For each COPC, either COPC-specific toxicity information was available or a suitable surrogate was available for at least one of the four types of toxicity values used in this HHRA (see Section 4.0).

When a surrogate was used, efforts were made to select the most toxic surrogate of those available to ensure that this HHRA is sufficiently health-protective. However, it is important to recognize that the use of a surrogate could result in the over- or under-estimation of risk estimates. Because surrogates were used for relatively few COPCs, and health-protective surrogates were selected, this issue does not represent a significant source of uncertainty in this HHRA.

6.3 Risk Characterization

This section addresses uncertainties related to the calculated risk estimates for the Study Area, including risks associated with non-detected COPCs (Section 6.3.1) and current outdoor workers (Section 6.3.2).

¹⁵ Carcinogenic toxicity values were only compiled for those chemicals classified as carcinogens (see Section 4 for additional information).

6.3.1 Non-Detected COPCs

As indicated in Section 3.2.2, risks were characterized only for those COPCs that were detected in the medium specific to that exposure scenario. Some COPCs in each scenario were never detected, but a sufficient number of sample RLs exceeded the applicable RSLs, and thus were identified as COPCs (see Section 3.2).

To provide a brief assessment of the hypothetical risks associated with these COPCs, half of the maximum RLs were compared with the applicable RSLs for each scenario-media combination (Tables 6-10 to 6-17).

Table 6-10. Summary of COPCs with Non-Detected Concentrations for the Industrial (Construction/Trenching) Worker RME Scenario Based on Exposure to Facility Soil

Non-Detected COPC	Unit	Detection Frequency Ratio	RL or Range of RLs	Mean Detect	Mean Value	Worker Soil RSL ^a	No. of Non-Detected Concentrations > RSL ^a	Maximum EF (half RL) ^b
Other SVOCs								
2,6-Dinitrotoluene	µg/kg dw	0/46	98 U – 8,830 U	nd	590	1,700	9	2.6
3,3'-Dichlorobenzidine	µg/kg dw	0/44	98 U – 4,420 U	nd	380	200	30	11
N-Nitroso-di-n-propylamine	µg/kg dw	0/46	98 U – 2,200 U	nd	190	250	16	4.4
Pesticides								
Dieldrin	µg/kg dw	0/115	0.6 U – 9,600 U	nd	90	110	17	44
alpha-BHC	µg/kg dw	0/115	0.6 U – 4,800 U	nd	40	35	22	69
Toxaphene	µg/kg dw	0/115	96 UJ – 480,000 U	nd	9,000	1,600	53	150
VOCs								
1,2-Dibromo-3-chloropropane	µg/kg dw	0/113	3 UJ – 5,600 U	nd	80	73	12	38
1,2-Dibromoethane (EDB)	µg/kg dw	0/113	0.9 U – 1,100 U	nd	10	0.44	113	1,250
1,2-Dichloroethane	µg/kg dw	0/113	0.9 U – 1,100 U	nd	10	7.4	12	74
Bromodichloromethane	µg/kg dw	0/113	0.9 U – 1,100 U	nd	10	23	12	24
Bromomethane	µg/kg dw	0/113	0.9 U – 1,100 U	nd	10	39	12	14
Carbon tetrachloride	µg/kg dw	0/113	0.9 U – 1,100 U	nd	10	70	12	7.9
Chloroform	µg/kg dw	0/113	0.9 U – 1,100 U	nd	10	18	12	31

^a The worker soil RSL is the lowest of EPA industrial screening levels (2009i) and DEQ human health occupational, construction worker, or excavation worker RBCs for the following four exposure routes: soil ingestion, dermal absorption, and inhalation; volatilization to outdoor air; and leaching to groundwater (2007b).

^b The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.

BHC – benzene hexachloride
 COPC – contaminant of potential concern
 dw – dry weight
 EDB – ethylene dibromide
 EF – exceedance factor

EPA – US Environmental Protection Agency
 nd – not detected
 RBC – risk-based concentration
 RL – reporting limit
 RME – reasonable maximum exposure

RSL – regional screening level
 SVOC – semivolatile organic compound
 U – not detected at given concentration
 VOC – volatile organic compound

Table 6-11. Summary of COPCs with Non-Detected Concentrations for the Industrial (Construction/Trenching) Worker RME Scenario Based on Exposure to Groundwater

Non-Detected COPC	Unit	Detection Frequency Ratio	RL or Range of RLs	Mean Detect	Mean Value	Worker Water RSL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
PAHs								
cPAH TEQ	µg/L	0/28	0.0910 U – 1.50 U	nd	0.186	0.0029	28	260
Other SVOCs								
2,6-Dinitrotoluene	µg/L	0/6	3.7 U – 4 U	nd	2	3.7	3	0.5
3,3'-Dichlorobenzidine	µg/L	0/6	1.8 U – 2 U	nd	0.9	0.13	6	7.7
Hexachlorobenzene	µg/L	0/28	0.0050 U – 0.4 U	nd	0.04	0.035	6	5.7
Pentachlorophenol	µg/L	0/6	1.8 U – 2 U	nd	0.9	0.47	6	2.1
PCBs								
Total PCBs	µg/L	0/28	0.10 U – 0.96 U	nd	0.14	0.028	28	17
Pesticides								
Aldrin (total) ^c	µg/L	0/28	0.0050 U – 0.019 U	nd	0.0039	0.0033	28	2.9
Dieldrin (total) ^c	µg/L	0/28	0.010 U – 0.019 U	nd	0.0059	0.0035	28	2.7
alpha-BHC	µg/L	0/28	0.0050 U – 0.019 U	nd	0.0039	0.009	6	1.1
Heptachlor	µg/L	0/28	0.0050 U – 0.024 U	nd	0.0043	0.013	7	0.9
Heptachlor epoxide	µg/L	0/28	0.0050 U – 0.019 U	nd	0.0039	0.0062	6	1.5
Toxaphene (total) ^v	µg/L	0/28	0.50 U – 4.8 U	nd	0.69	0.052	28	46
VOCs								
1,2-Dibromoethane (EDB)	µg/L	0/28	0.20 U – 1.0 U	nd	0.5	0.0057	28	88
1,2-Dichloroethane	µg/L	0/28	0.20 U – 1.0 U	nd	0.5	0.13	28	3.8
Bromodichloromethane	µg/L	0/28	0.20 U – 1.0 U	nd	0.5	0.18	28	2.8
Bromomethane	µg/L	0/28	0.50 U – 1.0 U	nd	0.5	0.85	25	0.6
Carbon tetrachloride	µg/L	0/28	0.20 U – 1.0 U	nd	0.5	0.17	28	2.9
Chloroform	µg/L	0/28	0.20 U – 1.0 U	nd	0.5	0.18	28	2.8
Trichloroethene	µg/L	0/28	0.20 U – 1.0 U	nd	0.5	0.029	28	17

- ^a The worker water RSL is the lowest of EPA water screening levels (2009i) and DEQ human health occupational RBCs for the following four exposure pathways: ingestion and inhalation from tap water, volatilization to outdoor air, and exposure to groundwater during excavation (2007b).
- ^b The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.
- ^c For this COPC, both total and dissolved concentrations were analyzed. To be conservative, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

BHC – benzene hexachloride
 COPC – contaminant of potential concern
 cPAH – carcinogenic PAH
 dw – dry weight
 EDB – ethylene dibromide
 EF – exceedance factor

EPA – US Environmental Protection Agency
 nd – not detected
 PAH – polycyclic aromatic hydrocarbon
 PCB – polychlorinated biphenyl
 RBC – risk-based concentration
 RL – reporting limit

RME – reasonable maximum exposure
 RSL – regional screening level
 SVOC – semivolatile organic compound
 TEQ – toxic equivalent
 U – not detected at given concentration
 VOC – volatile organic compound

Table 6-12. Summary of COPCs with Non-Detected Concentrations for the Future Outdoor Worker RME Scenario Based on Exposure to Facility Soil

Non-Detected COPC	Unit	Detection Frequency Ratio	RL or Range of RLs	Mean Detect	Mean Value	Worker Soil RSL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
Other SVOCs								
2,6-Dinitrotoluene	µg/kg dw	0/37	98 U – 8,830 U	nd	660	1,700	7	2.6
3,3'-Dichlorobenzidine	µg/kg dw	0/36	98 U – 4,420 U	nd	420	200	27	11
N-Nitroso-di-n-propylamine	µg/kg dw	0/37	98 U – 2,200 U	nd	220	250	16	4.4
Pesticides								
Aldrin	µg/kg dw	0/72	0.6 U – 4,800 U	nd	60	100	8	24
Dieldrin	µg/kg dw	0/72	0.6 U – 9,600 U	nd	100	110	16	44
alpha-BHC	µg/kg dw	0/72	0.6 U – 4,800 U	nd	60	35	19	69
gamma-BHC	µg/kg dw	0/72	0.6 U – 4,800 U	nd	60	100	8	24
Heptachlor epoxide	µg/kg dw	0/72	0.6 U – 4,800 U	nd	80	190	8	13
Toxaphene	µg/kg dw	0/72	97 UJ – 480,000 U	nd	12,000	1,600	39	150
VOCs								
1,2-Dibromoethane (EDB)	µg/kg dw	0/69	0.9 U – 1,100 U	nd	20	0.44	69	1,250

^a The worker soil RSL is the lowest of EPA industrial screening levels (2009i) and DEQ human health occupational, construction worker, or excavation worker RBCs for the following four exposure routes: soil ingestion, dermal absorption, and inhalation; volatilization to outdoor air; and leaching to groundwater (2007b).

^b The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.

BHC –benzene hexachloride
 COPC – contaminant of potential concern
 dw – dry weight
 EDB – ethylene dibromide
 EF – exceedance factor

EPA – US Environmental Protection Agency
 nd – not detected
 RBC –risk-based concentration
 RL – reporting limit
 RME – reasonable maximum exposure

RSL – regional screening level
 SVOC – semivolatile organic compound
 U– not detected at given concentration
 VOC –volatile organic compound

Table 6-13. Summary of COPCs with Non-Detected Concentrations for the Industrial/Commercial Worker Vapor Intrusion Scenario Based on Exposure to Groundwater

Non-Detected COPC	Unit	Detection Frequency Ratio	RL or Range of RLs	Mean Detect	Mean Value	EPA SL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
Other SVOCs								
Hexachlorobutadiene	µg/L	0/6	0.0050 U – 0.4 U	nd	0.07	0.33	2	0.6
VOCs								
1,1-Dichloropropene	µg/L	0/4	1.0 U	nd	0.5	0.84	4	0.6
1,2-Dibromoethane (EDB)	µg/L	0/6	1.0 U	nd	0.5	0.36	6	1.4
Bromoform	µg/L	0/6	1.0 U	nd	0.5	0.0083	6	60
cis-1,2- Dichloropropene	µg/L	0/6	1.0 U	nd	0.5	0.84	6	0.6
trans-1,2- Dichloropropene	µg/L	0/6	0.94 U – 1.0 U	nd	0.5	0.84	6	0.6

^a The EPA SL is from EPA's *Guidance for evaluating the vapor intrusion to indoor air pathway from groundwater and soils* (EPA 2002c).

^b The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.

COPC – contaminant of potential concern

dw – dry weight

EDB – ethylene dibromide

EF – exceedance factor

EPA – US Environmental Protection Agency

nd – not detected

RBC –risk-based concentration

RL – reporting limit

RSL – regional screening level

SL – screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

U – not detected at given concentration

VOC –volatile organic compound

Table 6-14. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Wetland Soil

Non-Detected COPC	Unit	Detection Frequency Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Residential/ Recreational Soil RSL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
Metals									
Thallium	mg/kg dw	0/5	nd	0.3 U – 0.75 U	nd	0.3	0.51	3	0.7
Other SVOCs									
2,4-Dinitrophenol	µg/kg dw	0/14	nd	200 U – 17,700 U	nd	2,500	12000	3	0.7
2,4-Dinitrotoluene	µg/kg dw	0/15	nd	98 U – 5,200 U	nd	430	1600	2	1.6
2,6-Dinitrotoluene	µg/kg dw	0/15	nd	98 U – 8,830 U	nd	1,200	420	8	11
3,3'-Dichlorobenzidine	µg/kg dw	0/14	nd	98 U – 5,200 U	nd	760	28	14	93
4,6-Dinitro-o-cresol	µg/kg dw	0/14	nd	200 U – 10,000 U	nd	1,500	610	8	8.2
Atrazine	µg/kg dw	0/5	nd	973 U – 4,420 U	nd	1,440	2100	3	1.1
bis(2-chloroethyl)ether	µg/kg dw	0/15	nd	20 U – 1,000 U	nd	140	190	6	2.6
N-Nitroso-di-n-propylamine	µg/kg dw	0/15	nd	98 U – 5,200 U	nd	330	69	15	38
Pentachlorophenol	µg/kg dw	1/15	80 J	98 U – 5,200 U	80	720	480	7	5.4
Pesticides									
Aldrin	µg/kg dw	0/61	nd	0.92 U – 490 U	nd	12	29	7	8.4
Dieldrin	µg/kg dw	0/61	nd	0.97 U – 980 U	nd	23	23	32	21
alpha-BHC	µg/kg dw	0/61	nd	0.92 U – 490 U	nd	12	4.8	35	51
gamma-BHC	µg/kg dw	0/61	nd	0.92 U – 490 U	nd	12	14	21	18
Toxaphene	µg/kg dw	0/61	nd	96 U – 49,000 U	nd	2,900	440	48	56
VOCs									
1,2-Dibromo-3-chloropropane	µg/kg dw	0/52	nd	3 UJ – 150 UJ	nd	8	5.6	44	13
1,2-Dibromoethane (EDB)	µg/kg dw	0/52	nd	0.9 U – 15 U	nd	1	0.073	52	100
1,2-Dichloroethane	µg/kg dw	0/52	nd	0.9 U – 15 U	nd	1	1.2	43	6.3
Bromodichloromethane	µg/kg dw	0/52	nd	0.9 U – 15 U	nd	1	3.9	10	1.9

Table 6-14. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Wetland Soil

Non-Detected COPC	Unit	Detection Frequency Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Residential/Recreational Soil RSL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
Chloroform	µg/kg dw	0/52	nd	0.9 U – 15 U	nd	1	3.1	13	2.4
Vinyl chloride	µg/kg dw	0/52	nd	0.9 U – 15 U	nd	1	0.5	52	15

^a The residential/recreational soil RSL is the lowest of EPA residential screening levels (2009i) and DEQ RBCs through soil ingestion, dermal contact, and inhalation; residential exposure through volatilization to outdoor air; and residential exposure through leaching to groundwater (2007b).

^b The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.

BHC –benzene hexachloride

COPC – contaminant of potential concern

dw – dry weight

EDB – ethylene dibromide

EF – exceedance factor

EPA – US Environmental Protection Agency

J – estimated concentration

nd – not detected

RBC –risk-based concentration

RL – reporting limit

RME – reasonable maximum exposure

RSL – regional screening level

SVOC – semivolatile organic compound

U – not detected at given concentration

VOC –volatile organic compound

Table 6-15. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Sediment

Non-Detected COPC	Unit	Detection Frequency Ratio	RL or Range of RLs	Mean Detect	Mean Value	Residential/Recreational Soil RSL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
Pesticides								
Dieldrin	µg/kg dw	0/11	4.8 U – 25 U	nd	11	23	9	0.5
alpha-BHC	µg/kg dw	0/11	2.4 U – 12 U	nd	5.1	4.8	9	1.3
Toxaphene	µg/kg dw	0/11	970 U – 5,000 U	nd	2,100	440	11	5.7
VOCs								
1,2-Dibromo-3-chloropropane	µg/kg dw	0/11	5.3 U – 41 U	nd	15	5.6	9	3.7
1,2-Dibromoethane (EDB)	µg/kg dw	0/11	1.1 U – 8.2 U	nd	3.0	0.073	11	56
1,2-Dichloroethane	µg/kg dw	0/11	1.1 U – 8.2 U	nd	3.0	1.2	9	3.4
Benzene	µg/kg dw	0/11	1.1 U – 8.2 U	nd	3.0	8.4	0	0.49
Bromodichloromethane	µg/kg dw	0/11	1.1 U – 8.2 U	nd	3.0	3.9	8	1.1
Chloroform	µg/kg dw	0/11	1.1 U – 8.2 U	nd	3.0	3.1	9	1.3
Trichloroethene	µg/kg dw	0/11	1.1 U – 8.2 U	nd	3.0	1.7	9	2.4
Vinyl chloride	µg/kg dw	0/11	1.1 U – 8.2 U	nd	3.0	0.5	11	8.2

^a The residential/recreational sediment RSL is the lowest of EPA residential screening levels (2009i) and DEQ RBCs through soil ingestion, dermal contact, and inhalation; residential exposure through volatilization to outdoor air; and residential exposure through leaching to groundwater (2007b). Soil RSLs are used because no sediment-specific RSLs are available.

^b The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.

BHC –benzene hexachloride

dw – dry weight

EDB – ethylene dibromide

EF – exceedance factor

EPA – US Environmental Protection Agency

nd – not detected

RBC –risk-based concentration

RL – reporting limit

RME – reasonable maximum exposure

RSL – regional screening level

U – not detected at given concentration

VOC –volatile organic compound

Table 6-16. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Surface Water

Non-Detected COPC	Unit	Detection Frequency Ratio	RL or Range of RLs	Mean Detect	Mean Value	Residential/Recreational Water RSL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
Metals								
Cobalt (total) ^c	µg/L	0/3	3 U	nd	2	1.1	3	1.4
PAHs								
cPAH TEQ	µg/L	0/3	0.0910 U	nd	0.0455	0.0029	3	16
Other SVOCs								
1,2,4-Trichlorobenzene	µg/L	0/3	5.0 U	nd	2.5	0.82	3	3.0
1,4-Dichlorobenzene	µg/L	0/3	1.0 U	nd	0.50	0.43	3	1.2
Hexachlorobenzene	µg/L	0/3	0.0050 U	nd	0.0025	0.00028	3	8.9
PCBs								
Total PCBs	µg/L	0/3	0.10 UJ	nd	0.050	0.000064	3	780
Pesticides								
Aldrin	µg/L	0/3	0.0050 U	nd	0.0025	0.000049	3	51
Dieldrin	µg/L	0/3	0.010 U	nd	0.0050	0.000052	3	96
alpha-BHC	µg/L	0/3	0.0050 U	nd	0.0025	0.0026	3	1.0
beta-BHC	µg/L	0/3	0.0050 U – 0.024 U	nd	0.0057	0.0091	1	1.3
gamma-Chlordane	µg/L	0/3	0.0050 U	nd	0.0025	0.0008	3	3.1
Total chlordane	µg/L	0/3	0.0050 U	nd	0.0025	0.0008	3	3.1
Heptachlor	µg/L	0/3	0.0050 U	nd	0.0025	0.000079	3	32
Heptachlor epoxide	µg/L	0/3	0.0050 U	nd	0.0025	0.000039	3	64
Toxaphene	µg/L	0/3	0.50 U	nd	0.25	0.00028	3	890
VOCs								
1,1,1,2-Tetrachloroethane	µg/L	0/3	1.0 U	nd	0.50	0.52	3	1.0
1,1,2,2-Tetrachloroethane	µg/L	0/3	1.0 U	nd	0.50	0.067	3	7.5
1,1,2-Trichloroethane	µg/L	0/3	1.0 U	nd	0.50	0.24	3	2.1
1,2,3-Trichloropropane	µg/L	0/3	2.0 U	nd	1.0	0.0096	3	100

Table 6-16. Summary of COPCs with Non-Detected Concentrations for the Force Lake Recreational User RME Scenario Based on Exposure to Lake Surface Water

Non-Detected COPC	Unit	Detection Frequency Ratio	RL or Range of RLs	Mean Detect	Mean Value	Residential/Recreational Water RSL ^a	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^b
1,2-Dibromo-3-chloropropane	µg/L	0/3	5.0 U	nd	2.5	0.00032	3	7,800
1,2-Dibromoethane (EDB)	µg/L	0/3	1.0 U	nd	0.50	0.0057	3	88
1,2-Dichloroethane	µg/L	0/3	1.0 U	nd	0.50	0.13	3	3.8
1,2-Dichloropropane	µg/L	0/3	1.0 U	nd	0.50	0.39	3	1.3
Benzene	µg/L	0/3	1.0 U	nd	0.50	0.35	3	1.4
Bromodichloromethane	µg/L	0/3	1.0 U	nd	0.50	0.12	3	4.2
Bromomethane	µg/L	0/3	1.0 U	nd	0.50	0.85	3	0.6
Carbon tetrachloride	µg/L	0/3	1.0 U	nd	0.50	0.17	3	2.9
Chloroform	µg/L	0/3	1.0 U	nd	0.50	0.18	3	2.8
cis-1,3-Dichloropropene	µg/L	0/3	1.0 U	nd	0.50	0.34	3	1.5
Dibromochloromethane	µg/L	0/3	1.0 U	nd	0.50	0.15	3	3.3
Tetrachloroethene	µg/L	0/3	1.0 U	nd	0.50	0.11	3	4.5
trans-1,3-Dichloropropene	µg/L	0/3	1.0 U	nd	0.50	0.34	3	1.5
Trichloroethene	µg/L	0/3	1.0 U	nd	0.50	0.029	3	17
Vinyl chloride	µg/L	0/3	1.0 U	nd	0.50	0.016	3	31

^a The residential/recreational water RSL is the lowest of EPA AWQC for human water/ organism consumption and organism consumption (2009c), EPA water screening levels (2009i), and DEQ human health occupational RBCs for the following four pathways: ingestion and inhalation from tap water, volatilization to outdoor air, and exposure to groundwater during excavation (2007b).

^b The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.

^c For this COPC, both total and dissolved concentrations were analyzed. To be conservative, the total fraction was assessed in this HHRA because it is slightly higher than the dissolved fraction.

AWQC – ambient water quality criteria

BHC –benzene hexachloride

COPC – contaminant of potential concern

cPAH – carcinogenic PAH

dw – dry weight

EDB – ethylene dibromide

EF – exceedance factor

EPA – US Environmental Protection Agency

nd – not detected

PAH – polycyclic aromatic hydrocarbon

PCB –polychlorinated biphenyl

RBC –risk-based concentration

RL – reporting limit

RME – reasonable maximum exposure

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

U – not detected at given concentration

VOC –volatile organic compound

Table 6-17. Summary of COPCs with Non-Detected Concentrations for the Force Lake Fish Consumer RME Scenario Based on Exposure to Calculated Fish Tissue

Non-Detected COPC	Unit	Detection Frequency Ratio	Sediment Concentrations (dw)		BSAF ^a	Calculated Fish Tissue Concentrations (ww) ^b		Fish RSL (mg/kg ww) ^c	No. of Non-Detected Concentrations > RSL	Maximum EF (half RL) ^d
			Range of RLs	Mean Value		Range of RLs	Mean Value			
Metals										
Antimony	mg/kg	0/11	0.3 UJ – 1 UJ	0.4	1	0.06 UJ – 0.2 UJ	0.08	0.0541	9	1.8
Selenium	mg/kg	0/11	0.7 U – 4 U	2	1	0.14 U – 0.8 U	0.4	0.676	0	0.6
Pesticides										
Aldrin	µg/kg	0/11	2.4 U – 12 U	5.1	1	0.0014 U – 0.0068 U	0.0029	0.000186	11	18
Dieldrin	µg/kg	0/11	4.8 U – 25 U	11	2.2	0.0060 U – 0.031 U	0.014	0.000197	11	80
alpha-BHC	µg/kg	0/11	2.4 U – 12 U	5.1	1	0.0014 U – 0.0068 U	0.0029	0.000501	11	6.7
beta-BHC	µg/kg	0/11	2.4 U – 23 U	5.7	1	0.0014 U – 0.013 U	0.0032	0.00175	9	3.7
gamma-BHC	µg/kg	0/11	2.4 U – 12 U	5.1	1	0.0014 U – 0.0068 U	0.0029	0.00287	9	1.2
alpha-Chlordane	µg/kg	0/11	2.4 U – 12 U	5.1	1.5	0.0020 U – 0.0099 U	0.0042	0.00901	0	0.5
Total chlordane	µg/kg	0/11	2.4 U – 12 U	5.1	26	0.035 U – 0.18 U	0.075	0.00901	11	10
Heptachlor	µg/kg	0/11	2.4 U – 12 U	5.1	0.13	0.00018 U – 0.00088 U	0.00070	0.000701	0	0.6
Heptachlor epoxide	µg/kg	0/11	2.4 U – 12 U	5.1	29	0.039 U – 0.20 U	0.83	0.000347	11	280
Toxaphene	µg/kg	0/11	970 U – 5,000 U	2,100	1	0.55 U – 2.8 U	1.2	0.00287	11	490
VOCs										
1,2,3-Trichloropropane	µg/kg	0/11	2.1 U – 16 U	5.8	1	0.0012 U – 0.0090 U	0.0033	0.000451	11	10
1,2-Dibromo-3-chloropropane	µg/kg	0/11	5.3 U – 41 U	15	1	0.0030 U – 0.023 U	0.0085	0.00394	9	2.9
Benzene	µg/kg	0/11	1.1 U – 8.2 U	3.0	1	0.00062 U – 0.0046 U	0.0017	0.0574	0	0.04
Vinyl chloride	µg/kg	0/11	1.1 U – 8.2 U	3.0	1	0.00062 U – 0.0046 U	0.0017	0.00438	0	0.5

^a BSAF units are dw/dw for metals, and are lipid/OC for all other COPCs.

^b Fish tissue concentrations are estimated based on the sediment concentrations and BSAFs presented in this table (see Attachment 2 for additional information regarding the methodology used to calculate tissue concentrations).

^c Fish RSLs are taken from EPA Region 3 RBC tables (2009h).

^d The EF provides a comparison of half of the maximum RL and the RSL and was calculated by dividing the half RL by the RSL. An EF greater than 1 indicates that the half RL is greater than the RSL.

BHC –benzene hexachloride

COPC – contaminant of potential concern

dw – dry weight

EF – exceedance factor

EPA – US Environmental Protection Agency

J – estimated concentration

RL – reporting limit

RME – reasonable maximum exposure

RSL – regional screening level

U – not detected at given concentration

VOC –volatile organic compound

As can be seen in Tables 6-10 to 6-17, the EFs based on half of the maximum RL ranged from 0.5 up to 7,800. Of the EFs presented in these tables, most were less than 100 (92%), and the majority were less than 10 (62%). Because these EFs were based on reporting limits, not detected concentrations, they are highly uncertain and do not necessarily indicate the level of risk associated with these COPCs. Despite the uncertainty surrounding the risks associated with non-detected COPCs (i.e., because of the uncertainty in the exposure concentrations for non-detected COPCs), this analysis indicates that high risks from these COPCs are unlikely. Thus, the potential impact of this uncertainty on the risk estimates in this HHRA is low.

6.3.2 Risks to Current Outdoor Workers

The soil berm surrounding the Facility and the soil stockpile on the northern portion of the Facility are not covered in gravel or pavement and are thus accessible to current outdoor workers (see Figure 1-2 and 2-1 for the location of these samples). The exposure potential for current workers at the Facility to contact the soil berm or soil stockpile is low based on activities conducted at the Facility and based on the location of this soil (i.e., not in normal work areas).

Despite this low exposure potential, risks associated with the soil berm and soil stockpile were evaluated by screening contaminant concentrations in soil against worker RSLs. Six contaminants were detected in the soil berm at concentrations greater than the industrial RSL (arsenic, copper, lead, cPAH TEQ, total PCBs, and total DDTs), and two contaminants were detected in the soil stockpile at concentrations greater than the industrial RSL (arsenic and lead). These contaminants are discussed further below:

- **Arsenic:** eight of the nine soil berm and all of the three soil stockpile samples had arsenic concentrations greater than the industrial RSL. However, of these samples, only one soil berm sample had an arsenic concentration that was greater than the regional soil background concentration of 7 mg/kg dw (see Attachment 7).
- **Copper:** one of the nine soil berm samples and none of the soil stockpile samples had copper concentrations that were greater than the industrial RSL. The one soil berm sample with a copper concentration that was greater than the RSL had an exceedance factor of 1.1, while the average soil berm exceedance factor was well below 1 (equal to 0.2).
- **Lead:** All of the nine soil berm and all of the three soil stockpile samples had lead concentrations that were greater than the industrial RSL. However, all of these samples had concentrations that were within a factor of 3 of the regional soil background concentration of 17 mg/kg dw (see Attachment 7), and most were within a factor of 2 of this background concentration.

- **cPAH TEQ:** three of the nine soil berm and none of the soil stockpile samples had cPAH TEQs that were greater than the industrial RSL. Exceedance factors for these samples were 1.6, 1.7, and 23, with a mean exceedance factor across the nine berm samples of 3.0. The high exceedance factor of 23 was for location SB-06 in the northwest corner of the Facility.
- **Total PCBs:** one of the nine soil berm and none of the soil stockpile samples had total PCB concentrations that were greater than the industrial RSL. The one soil berm sample with a concentration greater than the RSL had an exceedance factor of 1.0, while the average soil berm exceedance factor was below 1 (equal to 0.5).
- **Total DDTs:** one of the nine soil berm and none of the soil stockpile samples had total DDT concentrations greater than the industrial RSL. The one soil berm sample with a concentration greater than the RSL had an exceedance factor of 1.6, while the average soil berm exceedance factor was below 1 (equal to 0.3).

The exceedances of the industrial RSLs for contaminants detected in the soil berm and soil stockpile samples indicate that there could be some risk to current outdoor workers at the Facility. However, as previously noted, the low exposure potential of workers to this soil combined with the generally low contaminants concentrations indicates that risks associated with the soil berm and soil stockpile are low.

7.0 CONCLUSIONS

This baseline HHRA characterizes human health risks from site-related exposures in support of risk management decisions and the evaluation of remedial options. In addition, this HHRA serves to inform the public of health risks from exposures to contaminants at the Study Area. Scenarios evaluated in this HHRA included worker scenarios based on activities conducted at the Facility, recreational user scenarios associated with activities in Force Lake or the nearby wetlands, and a fish consumer scenario based on the consumption of fish from Force Lake.

Additionally, a screening level assessment was conducted to assess risks based on residential exposure. This screening assessment for hypothetical future residents indicated that the total excess cancer risks would be greater than the upper end of EPA's target risk range (10^{-4}), and that some chemicals would have an HQ greater than 1 based on a comparison of Study Area with regional screening levels (Attachment 1) if the land use designation for this area changed in the future. However, given the "Industrial Sanctuary" designation for the property on which the Facility is located and the fact that the non-Facility portions of the Study Area are in a natural resource management planning area established under the City of Portland planning code, these designations are not likely to change in the future.

This variety of exposure scenarios were evaluated to provide a range of risk estimates. Individuals can evaluate their own risks by comparing their behavior with the assumptions included in each of the exposure scenarios. A summary of the risk estimates is provided in Table 7-1. Additional summary information regarding the risk estimates and uncertainties associated with these estimates is provided in Section 5.5 (risk estimates) and Table 6-1 (uncertainties).

In Section 5, all COPCs with risk estimates for one or more scenarios greater than an excess cancer risk of 1×10^{-6} or a non-cancer HQ of 1 were identified as COCs (Table 7-1).

Table 7-1. Summary of Total Excess Cancer Risks and Non-Cancer HQs

Scenario Name	Total Excess Cancer Risk	Overall HI ^a	COCs
Facility Scenarios			
Industrial (construction/trenching) worker RME scenario: Facility soil	3×10^{-6}	1	none
Future outdoor worker RME scenario: Facility soil	2×10^{-5}	0.6	arsenic, cPAH TEQ, total PCBs, total DDTs, TPH-gasoline (aliphatic)
Industrial/commercial worker vapor intrusion scenario	9×10^{-7}	ne ^b	none
Non-Facility Scenarios			
Force Lake recreational user RME scenario: Wetland soil	9×10^{-6}	0.3 ^c	arsenic, cPAH TEQ
Force Lake recreational user RME scenario: Lake sediment	1×10^{-6}	0.08 ^c	none
Force Lake fish consumer RME scenario	2×10^{-5}	3 (endpoint-specific HIs were less than 1) ^{c, d}	arsenic, total PCBs, total DDTs

^a The overall HI is equal to the sum of HQs for all COPCs across multiple endpoints and/or target organs.

^b Risks for this scenario were calculated using the vapor intrusion screening levels, which are based on the more stringent of the cancer or non-cancer risks (i.e., whichever results in lower screening levels). For this scenario, screening levels for all COPCs were based on cancer risks, and thus it was not possible to calculate non-cancer risks.

^c The overall HI is for the 0 to 6-yr age group. These HQs are higher than HQs for the integrated 0-to-30 year age group and for older age groups (i.e., 7 to 16 years and 17 to 30 years), and thus are typically used for risk management decisions.

^d The overall HI for this scenario is equal to 3. Because this value is greater than 1, endpoint-specific HIs were calculated per EPA guidance (EPA 1989). No endpoint-specific HIs were greater than 1 (see Section 5.3.5 for details).

COCs – contaminants of concern

ne – not evaluated

COPC – contaminants of potential concern

RME – reasonable maximum exposure

cPAH – carcinogenic polycyclic aromatic hydrocarbon

TEQ – toxic equivalent

HI – hazard index

TPH – total petroleum hydrocarbons

HQ – hazard quotient

Table 7-2 presents a summary of the excess cancer risks and the percent contributions of each COC relative to the total excess cancer risk, based on Study Area concentrations and on background or reference area concentrations. No individual COPC non-cancer HQs or endpoint-specific HIs were greater than 1. The following subsections discuss each COC in greater detail.

Table 7-2. Summary of Risk Estimates and Percent Contribution of Total Risk for each COC

COC	Scenarios with Excess Cancer Risks Greater than 1×10^{-6}	Excess Cancer Risk (Percent Contribution to Total)	
		Study Area	Background or Reference Area ^a
Arsenic	future outdoor worker: Facility soil	7×10^{-6} (30%)	4×10^{-6}
	Force Lake recreational user: wetland soil	2×10^{-6} (23%)	2×10^{-6}
	Force Lake fish consumer	7×10^{-6} (37%)	8×10^{-6} to 9×10^{-6}
cPAH TEQ	future outdoor worker: Facility soil	4×10^{-6} (17%)	3×10^{-8} to 2×10^{-7}
	Force Lake recreational user: wetland soil	6×10^{-6} (68%)	4×10^{-8} to 3×10^{-7}
Total PCBs	future outdoor worker: Facility soil	6×10^{-6} (26%)	2×10^{-8}
	Force Lake fish consumer	1×10^{-5} (53%)	3×10^{-6} to 4×10^{-6}
Total DDTs	future outdoor worker: Facility soil	2×10^{-6} (9%)	2×10^{-9} to 5×10^{-8}
	Force Lake fish consumer	2×10^{-6} (11%)	2×10^{-7}
TPH-gasoline (aliphatic)	future outdoor worker: Facility soil	3×10^{-6} (13%)	ne

^a Background and reference area concentrations and sources are discussed in Attachment 7.

COC – contaminant of concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

ne – not evaluated

PCB – polychlorinated biphenyl

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

7.1 Arsenic

Arsenic was selected as a COC based on: 1) exposure to Facility soil for the outdoor worker scenario, 2) exposure to wetland soil for the recreational user scenario, and 3) exposure to lake sediment for the fish consumer scenario (Table 7-2). Arsenic made up 30, 23, and 37% of the estimated total excess cancer risks for these three scenarios, respectively. However, risk estimates based on background concentrations for arsenic were similar to those based on Study Area concentrations, and thus the consideration of background concentrations is important for arsenic. Arsenic concentrations in soil across much of the Study Area were less than or equal to the regional background soil concentration of 7 mg/kg dw (DEQ 2002, 2007a), although six soil samples collected in the former drainage ditch area to the northwest of the Facility and four samples in the west corner of the Facility had concentrations greater than this value.

7.2 cPAH TEQ

cPAH TEQ was selected as a COC based on exposure to Facility soil for the future outdoor worker scenario and based on exposure to wetland soil for the Force Lake recreational user scenario (Table 7-2). The excess cancer risk associated with cPAH TEQ was 17 and 68% of the total excess cancer risk for these two scenarios, respectively. Risk estimates based on reference area soil concentrations for cPAH TEQ were generally much less than those based on Study Area soil concentrations, indicating that reference area concentrations are not an important consideration for cPAH TEQ. The highest cPAH TEQs were detected in samples collected from the central portion of the Facility and at several locations in the former drainage ditch area to the northwest of the Facility.

7.3 Total PCBs

Total PCBs were selected as a COC based on exposure to Facility soil for the future outdoor worker RME scenario and based on exposure to lake sediment for the Force Lake fish consumer RME scenario (Table 7-2). The excess cancer risk associated with total PCBs was 26 and 53% of the total excess cancer risk estimates for these two scenarios, respectively. Risk estimates based on reference area concentrations for total PCBs were much less than those based on Study Area concentrations, indicating that reference area concentrations are not an important consideration for total PCBs.

Total PCB concentrations were highest (greater than 10,000 µg/kg dw) near the Facility entrance in the east corner of the Facility. Total PCB concentrations were also relatively high (greater than 1,000 µg/kg dw) in the central portion of the Facility and at several locations in the former drainage ditch area to the northwest of the Facility. Total PCB concentrations in Force Lake were much lower, ranging from non-detect to 131 µg/kg dw.

7.4 Total DDTs

Total DDTs were selected as a COC based on exposure to Facility soil for the future outdoor worker RME scenario and based on exposure to lake sediment for the Force Lake fish consumer RME scenario (Table 7-2). The excess cancer risks associated with total DDTs were less than the estimates for the other COCs and represented 11% or less of the total excess cancer risk for the future outdoor worker and Force Lake fish consumer RME scenarios. Risk estimates based on reference area concentrations for total DDTs were much less than those based on Study Area concentrations, indicating that reference area concentrations are not an important consideration for total DDTs.

Total DDT concentrations were highest in samples collected from the central portion of the Facility and along the southwest Facility boundary with the wetlands.

7.5 TPH-gasoline (aliphatic)

TPH-gasoline (aliphatic) was selected as a COC for the future outdoor worker RME scenario based on exposure to Facility soil. The excess cancer risk was equal to 3×10^{-6} for this scenario, which was 13% of the total.

No background concentrations were available from the sources evaluated for TPH-gasoline (aliphatic). At the Study Area, gasoline-range TPH was generally highest in the central portion of the Facility. In off-Facility portions of the Study Area, concentrations were highest in the wetlands near the southwest corner of the Facility and in Force Lake.

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ATTACHMENT 1 – HYPOTHETICAL FUTURE RESIDENT SCREENING ASSESSMENT

The hypothetical future resident screening assessment scenario was created in response to US Environmental Protection Agency (EPA) comments, which stated that an assessment of risks associated with residential living is necessary to determine if Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) actions are needed to restrict future residential land use (EPA 2007). As discussed in the remedial investigation/feasibility study work plan (Bridgewater et al. 2008), the wetlands are currently zoned as open space, and the Facility and other surrounding areas are currently zoned for industrial use. City of Portland planning documents indicate that these designations are not likely to change in the future, especially given the “Industrial Sanctuary” designation for the property where the Facility is located and the fact that the non-Facility portions of the Study Area are in a natural resource management planning area established under the City of Portland planning code. Based on this information, residential development in this area is unlikely.

Because no residential areas are currently located near the Facility and no residential developments are planned, the hypothetical future resident scenario was assessed using a screening approach, as requested by EPA. The screening assessment was based on exposure through the following routes:

- **Wetland soil and Facility soil:** dermal absorption and incidental ingestion (e.g., gardening or child play)
- **Groundwater:** dermal absorption, incidental ingestion (e.g., showering) or water ingestion (e.g., drinking water)

Because this scenario was evaluated as a screening assessment, no contaminant of potential concern (COPC) list was generated, but rather all contaminants of interest (COIs) were evaluated. Facility soil data, wetland soil data, and groundwater data were compared (separately) with cancer and non-cancer residential regional screening levels (RSLs), and groundwater data were compared with relevant drinking water criteria. In addition, groundwater data were compared with EPA maximum contaminant levels (MCLs) and non-zero MCL goals (MCLGs).

Published screening levels were used to screen data for risks to hypothetical future residents. The published screening levels consider the difference in child and adult exposure and are protective of both. An integrated lifetime approach was used to calculate residential RSLs based on carcinogenic risks. For residential RSLs based on non-cancer risks, child-specific parameters were generally used to account for the higher sensitivity of this population.

In this screening assessment, maximum concentrations were compared with cancer and non-cancer RSLs. Cancer risks were estimated by dividing the maximum concentration by the cancer RSL, and then multiplying by 1×10^{-6} , the excess cancer risk upon which the RSLs were based. Chemical-specific cancer risks were then summed to derive a total excess cancer risk estimate for all

chemicals. Non-cancer HQs were estimated by dividing the maximum concentration by the non-cancer RSL. No multiplication was needed to estimate the HQ because an HQ of 1 was used to develop the RSLs. Chemical-specific HQs were then summed, regardless of the endpoint on which the non-cancer RSL was based. It should be noted that these risk estimates likely overestimate risk because they are based on maximum concentrations rather than exposure point concentrations that reflect integrated exposure over an area. Furthermore, the sum of HQs that does not consider endpoint is not directly interpretable for risk assessment purposes. For the MCLs and non-zero MCLGs, risk estimates could not be calculated because these screening levels are not risk-based. Instead, exceedance factors (EFs), equal to the maximum concentrations divided by the MCL or non-zero MCLG, were calculated. The results of the hypothetical future resident screening assessment are summarized in Table 1.

Table 1. Summary of the Hypothetical Future Resident Screening Assessment

Exposure Medium	Criteria Source	Data	Total Risks (Detects)	
			Excess Cancer Risks	Sum of HQs
Soil	EPA residential RSLs	Facility soil: maximum concentration for each chemical in surface soil samples and soil berm samples (soil stockpile samples were not included, as indicated in the work plan (Bridgewater et al. 2008))	6×10^{-4}	39
		Wetland soil: maximum concentration for each chemical in surface samples (0 to 6 inches) and the top layer of subsurface cores (6 to 12 inches); residents would be unlikely to contact deeper soils	5×10^{-4}	13
Ground-water	EPA residential RSLs	Groundwater: maximum concentration for each chemical in shallow groundwater samples ^a	1×10^{-3}	23
	EPA MCL or non-zero MCLGs		Total EF = 35 (criteria are not risk-based, and thus risks could not be calculated)	

^a Groundwater is addressed as a potential source of drinking water because the concentration of total dissolved solids is less than 10,000 mg/L. This criterion is based on the standards for underground sources of drinking water as defined by the Safe Drinking Water Act and underground injection control regulations.

EF – exceedance factor

MCLG – maximum contaminant level goal

EPA – US Environmental Protection Agency

RSL – regional screening level

MCL – maximum contaminant level

As presented in Table 1, total excess cancer risks were greater than EPA's target risk range of 10^{-4} to 10^{-6} and the sum of HQs was greater than 1 for all exposure media. The results of this conservative screening assessment, which used maximum concentrations, are further discussed below:

- Facility soil:** Maximum concentrations in surface soil samples (with the exception of the soil stockpile samples¹) were compared with cancer and non-cancer RSLs, as presented in Table 2. Table 2 also presents summary statistics, including the detection frequency, concentration range, and mean concentration. Of the 120 chemicals or chemical groups detected in Facility soil, 8 (arsenic, carcinogenic polycyclic aromatic hydrocarbon [cPAH] toxic equivalent [TEQ], naphthalene, total polychlorinated biphenyls [PCBs], total dichlorodiphenyltrichloroethanes [DDTs], benzene, ethylbenzene, and vinyl chloride) had detected concentrations greater than the cancer RSLs, and 3 (cobalt, total PCBs, and total DDTs) had detected concentrations greater than the non-cancer RSLs. Based on maximum detected concentrations, the total excess cancer risk was equal to 6×10^{-4} , and the sum of non-cancer HQs was equal to 39.
- Wetland soil:** Maximum concentrations in surface and intermediate soil samples were compared with cancer and non-cancer RSLs, as presented in Table 3. Table 3 also presents summary statistics, including the detection frequency, concentration range, and mean concentration. Of the 100 chemicals or chemical groups detected in wetland soil, 5 (arsenic, cPAH TEQ, naphthalene, total PCBs, total DDTs) had detected concentrations greater than the cancer RSLs, and 5 (arsenic, cobalt, iron, total PCBs, and total DDTs) had detected concentrations greater than the non-cancer RSLs. Based on maximum detected concentrations, the total excess cancer risk was equal to 5×10^{-4} , and the sum of non-cancer HQs was equal to 13.
- Groundwater:** Maximum concentrations in shallow groundwater samples were compared with cancer and non-cancer RSLs as well as with EPA MCLs and non-zero MCLGs, as presented in Table 4. Table 4 also presents summary statistics, including the detection frequency, concentration range, and mean concentration. A total of 7 chemicals or chemical groups (arsenic, naphthalene, 1,4-dichlorobenzene, total DDTs, benzene, tert-butyl methyl ether, and vinyl chloride) had detected concentrations greater than the cancer RSLs, 6 (arsenic, cobalt, iron, manganese, benzene, and chlorobenzene) had detected concentrations greater than the non-cancer RSLs, and 4 (arsenic, lead, benzene, and chlorobenzene) had detected concentrations greater than their respective MCLs or non-zero MCLGs. Based on maximum detected concentrations, the total excess cancer risk was equal to 1×10^{-3} , and the total non-cancer HI was equal to 23. Because MCLs and non-zero MCLGs are not risk-based screening levels, a total EF was calculated. This number cannot be directly interpreted as a risk estimate.

Based on the risks calculated using maximum concentrations, total excess cancer risks would be greater than 1×10^{-4} (the upper end of EPA's target risk range), and non-cancer HQs for some chemicals would be above EPA's threshold of 1 (which would result in endpoint-specific HIs greater than 1).

¹ Soil stockpile samples were excluded from this analysis because the storage of soil at the Facility was intended to be temporary (Bridgewater et al. 2008; Windward and Bridgewater 2008). Note that concentrations in soil stockpile samples are within the range of Facility soil samples.

Because risks were calculated based on maximum concentrations (rather than an upper confidence limit on the mean [UCL]) they represent an overestimation of risks. However, because excess cancer risk estimates were greater than 1×10^{-4} and HQs for some contaminants were greater than 1 using the UCLs presented in the HHRA for select contaminants, risks would likely be greater than the target risk range if the land use designation for this area were to change and the area was developed for residential use. However, as discussed previously, current land zoning and future planning documents indicate that residential development in this area is unlikely.

Table 2. Comparison of Facility Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
Metals												
Aluminum	mg/kg dw	13/13	5,280 – 11,200	na	8,400	8,400				77,000	0.15	
Antimony	mg/kg dw	0/62	nd	0.2 – 4.5	nd	0.6				31		0.07
Arsenic	mg/kg dw	62/62	0.7 – 20.6 J	na	4	4	0.39	5 × 10 ⁻⁵		22	0.9	
Barium	mg/kg dw	62/62	36.5 – 1,170 J	na	200	200				15,000	0.08	
Beryllium	mg/kg dw	13/13	0.29 – 0.601	na	0.4	0.4	1,400	4 × 10 ⁻¹⁰		160	0.004	
Cadmium	mg/kg dw	39/62	0.2 – 3.76	0.2 – 0.3	0.6	0.4	1,800	2 × 10 ⁻⁹		70	0.05	
Calcium	mg/kg dw	13/13	3,040 – 18,500	na	8,700	8,700						
Chromium	mg/kg dw	62/62	4.0 – 76	na	20	20						
Cobalt	mg/kg dw	62/62	4.1 J – 32	na	10	10	370	9 × 10 ⁻⁸		23	1.4	
Copper	mg/kg dw	62/62	9.23 – 1,240 J	na	100	100				3,100	0.4	
Iron	mg/kg dw	13/13	1,400 – 46,200	na	28,000	28,000				55,000	0.8	
Lead	mg/kg dw	62/62	3 – 337	na	50	50				400	0.8	
Magnesium	mg/kg dw	13/13	2,880 – 5,370	na	3,800	3,800						
Manganese	mg/kg dw	13/13	158 – 977	na	470	470				1,800	0.5	
Mercury	mg/kg dw	31/62	0.03 – 6.69	0.04 – 0.06	0.4	0.2				23	0.3	
Nickel	mg/kg dw	62/62	4 – 50 J	na	20	20	13,000	4 × 10 ⁻⁹		1,500	0.03	
Selenium	mg/kg dw	4/62	0.1 – 0.7 J	0.1 – 0.7	0.3	0.3				390	0.002	
Silver	mg/kg dw	12/13	0.42 – 3.16	0.4	1	1				390	0.008	
Sodium	mg/kg dw	13/13	286 – 625	na	451	451						
Thallium	mg/kg dw	0/13	nd	0.3 – 0.75	nd	0.3						
Vanadium	mg/kg dw	62/62	29.4 J – 165	na	84	84				390	0.4	
Zinc	mg/kg dw	62/62	35 – 718 J	na	200	200				23000	0.03	
PAHs												
2-Chloronaphthalene	µg/kg dw	0/30	nd	20 – 440	nd	72				6,300,000		0.00003
2-Methylnaphthalene	µg/kg dw	53/66	13 – 29,000	5 – 131	2,000	2,000				310,000	0.09	
Acenaphthene	µg/kg dw	33/66	5.3 – 28,000	4.6 – 134	1,500	760				3,400,000	0.008	
Acenaphthylene	µg/kg dw	9/66	5.3 – 597	4.6 – 390	120	47						
Anthracene	µg/kg dw	55/66	7.9 – 110,000	5 – 131	2,600	2,200				17,000,000	0.006	
Benzo(g,h,i)perylene	µg/kg dw	58/66	5.7 – 1,400 J	14 – 665	260	240						
Dibenzofuran	µg/kg dw	42/66	5.1 – 18,000	5 – 131	720	470						
Fluoranthene	µg/kg dw	60/66	9.7 – 35,000	15 – 131	1,600	1,500				2,300,000	0.02	

Table 2. Comparison of Facility Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
Fluorene	µg/kg dw	35/66	7.2 – 40,000	4.6 – 134	1,900	990				2,300,000	0.02	
Naphthalene	µg/kg dw	45/66	5.8 – 19,000	5 – 242	1,100	740	3,600	5×10^{-6}		140,000	0.14	
Phenanthrene	µg/kg dw	60/66	7.9 – 77,000	9.7 – 131	2,600	2,400						
Pyrene	µg/kg dw	63/66	16 – 31,000	20 – 120	1,600	1,600				1,700,000	0.02	
cPAH TEQ	µg/kg dw	62/66	14.0 – 5,200	33 – 450	611	581	15	3×10^{-4}				
Phthalates												
Bis(2-ethylhexyl) phthalate	µg/kg dw	24/30	11 J – 5,730	56 – 133	1,300	1,000	35,000	2×10^{-7}		1,200,000	0.005	
Butyl benzyl phthalate	µg/kg dw	6/30	190 – 1,700	20 – 1,440	790	300	260,000	7×10^{-9}		12,000,000	0.00014	
Diethyl phthalate	µg/kg dw	1/30	184 J	20 – 440	184	75				49,000,000	4E-06	
Dimethyl phthalate	µg/kg dw	0/30	nd	20 – 577	nd	100						
Di-n-butyl phthalate	µg/kg dw	1/30	194	20 – 440	194	76				6,100,000	0.00003	
Di-n-octyl phthalate	µg/kg dw	0/30	nd	20 – 1,440	nd	200						
Other SVOCs												
1,2,4-Trichlorobenzene	µg/kg dw	2/62	7.2 J – 24 J	2.2 – 4,000	16	50	22,000	1×10^{-9}		62,000	0.0004	
1,2-Dichlorobenzene	µg/kg dw	11/61	1.3 JN – 980	0.9 – 440	110	30				1,900,000	0.0005	
1,3-Dichlorobenzene	µg/kg dw	4/60	1.4 J – 2.7 J	0.9 – 810	2.1	10						
1,4-Dichlorobenzene	µg/kg dw	13/61	2.2 – 99	0.9 – 810	19	20	2,400	4×10^{-8}		3,500,000	0.00003	
2,4,5-Trichlorophenol	µg/kg dw	0/30	nd	98 – 2,200	nd	360				6,100,000		0.0002
2,4,6-Trichlorophenol	µg/kg dw	0/30	nd	98 – 2,200	nd	270	44,000		3×10^{-8}	61,000		0.02
2,4-Dichlorophenol	µg/kg dw	0/30	nd	98 – 2,200	nd	230				180,000		0.006
2,4-Dimethylphenol	µg/kg dw	3/30	70 – 480	20 – 440	260	93				1,200,000	0.0004	
2,4-Dinitrophenol	µg/kg dw	0/28	nd	200 – 5,770	nd	1,100				120,000		0.02
2,4-Dinitrotoluene	µg/kg dw	0/30	nd	98 – 2,200	nd	270	1,600		7×10^{-7}	120,000		0.009
2,6-Dinitrotoluene	µg/kg dw	0/30	nd	98 – 2,880	nd	520				61,000		0.02
2-Chlorophenol	µg/kg dw	0/30	nd	20 – 440	nd	72				390,000		0.0006
2-Methylphenol	µg/kg dw	2/30	163 – 518	20 – 440	341	90				3,100,000	0.0002	
2-Nitroaniline	µg/kg dw	0/30	nd	98 – 2,200	nd	270				610,000		0.002
2-Nitrophenol	µg/kg dw	0/30	nd	98 – 2,200	nd	360						
3,3'-Dichlorobenzidine	µg/kg dw	0/29	nd	98 – 2,200	nd	370	1,100		1×10^{-6}			
3-Nitroaniline	µg/kg dw	0/30	nd	98 – 2,200	nd	360						
4,6-Dinitro-o-cresol	µg/kg dw	0/30	nd	200 – 4,400	nd	720				4,900		0.4
4-Bromophenyl phenyl ether	µg/kg dw	0/30	nd	20 – 440	nd	72						
4-Chloro-3-methylphenol	µg/kg dw	0/30	nd	98 – 2,200	nd	360						

Table 2. Comparison of Facility Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
4-Chloroaniline	µg/kg dw	0/30	nd	98 – 2,200	nd	270	2,400		5×10^{-7}	240,000		0.005
4-Chlorophenyl phenyl ether	µg/kg dw	0/30	nd	20 – 440	nd	72						
4-Methylphenol	µg/kg dw	4/30	58 – 1,240	20 – 440	600	140				310,000	0.004	
4-Nitroaniline	µg/kg dw	0/30	nd	98 – 2,200	nd	360	24,000		5×10^{-8}	240,000		0.005
4-Nitrophenol	µg/kg dw	0/30	nd	98 – 2,880	nd	520						
Acetophenone	µg/kg dw	2/13	68.2 J – 307	119 – 1,730	188	180				7,800,000	0.00004	
Aniline	µg/kg dw	0/16	nd	20 – 440	nd	72	85,000		3×10^{-9}	430,000		0.0005
Atrazine	µg/kg dw	0/13	nd	596 – 1,440	nd	375	2,100		3×10^{-7}	2,100,000		0.0003
Benzaldehyde	µg/kg dw	1/12	37.2 J	119 – 288	37.2	73.6				7,800,000	0.000005	
Benzoic acid	µg/kg dw	0/17	nd	200 – 4,400	nd	700				240,000,000		0.000009
Benzyl alcohol	µg/kg dw	0/17	nd	20 – 440	nd	70				6,100,000		0.00004
Biphenyl	µg/kg dw	5/13	44.7 J – 1,000	119 – 254	300	200				3,900,000	0.0003	
bis(2-chloroethoxy)methane	µg/kg dw	0/30	nd	20 – 440	nd	72				180,000		0.001
bis(2-chloroethyl)ether	µg/kg dw	0/30	nd	20 – 440	nd	72	210		1×10^{-6}			
bis(2-chloroisopropyl)ether	µg/kg dw	0/30	nd	20 – 440	nd	72	4,600		5×10^{-8}	3,100,000		0.00007
Caprolactam	µg/kg dw	0/13	nd	596 – 1,440	nd	375				31,000,000		0.00002
Carbazole	µg/kg dw	6/30	40 – 940	20 – 440	270	110						
Hexachlorobenzene	µg/kg dw	2/65	42 – 230	0.97 – 4,800	140	89	300	8×10^{-7}		49,000	0.005	
Hexachlorobutadiene	µg/kg dw	0/65	nd	0.97 – 4,000	nd	50	6,200		3×10^{-7}	61,000		0.03
Hexachlorocyclopentadiene	µg/kg dw	0/29	nd	98 – 2,200	nd	370				370,000		0.003
Hexachloroethane	µg/kg dw	0/30	nd	20 – 440	nd	72	35,000		6×10^{-9}	61,000		0.004
Isophorone	µg/kg dw	0/30	nd	20 – 440	nd	72	510,000		4×10^{-10}	12,000,000		0.00002
Nitrobenzene	µg/kg dw	0/30	nd	20 – 2,000	nd	120	4,800		2×10^{-7}	130,000		0.008
n-Nitroso-di-n-propylamine	µg/kg dw	0/30	nd	98 – 2,200	nd	230	69		2×10^{-5}			
n-Nitrosodiphenylamine	µg/kg dw	0/30	nd	20 – 2,500	nd	150	99,000		1×10^{-8}			
Pentachlorophenol	µg/kg dw	0/30	nd	98 – 2,200	nd	360	3,000		4×10^{-7}	1,400,000		0.0008
Phenol	µg/kg dw	2/30	156 – 825	20 – 440	491	100				18,000,000	0.00005	
PCBs												
Total PCBs	µg/kg dw	52/64	4.9 J – 32,000	32 – 160	2,000	2,000	220	1×10^{-4}		1,100	29	
Pesticides												
Total DDTs	µg/kg dw	62/65	5.0 – 78,000 J	0.6 – 2	7,000	7,000	1700	5×10^{-5}		36,000	2.2	
Aldrin	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70	29		8×10^{-5}	1,800		1.3
Dieldrin	µg/kg dw	0/65	nd	0.6 – 9,600	nd	100	30		2×10^{-4}	3,100		1.5

Table 2. Comparison of Facility Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
alpha-BHC	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70	77		3×10^{-5}	490,000		0.005
beta-BHC	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70	270		9×10^{-6}			
gamma-BHC	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70	520		5×10^{-6}	21,000		0.1
delta-BHC	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70						
alpha-Chlordane	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70						
gamma-Chlordane	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70						
Total chlordane	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70	1,600		2×10^{-6}	35,000		0.07
alpha-Endosulfan	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70				370,000		0.006
beta-Endosulfan	µg/kg dw	0/65	nd	0.6 – 9,600	nd	100						
Endosulfan sulfate	µg/kg dw	0/65	nd	0.6 – 9,600	nd	200						
Endrin	µg/kg dw	1/65	2.6	0.6 – 9,600	2.6	100				18,000	0.0001	
Endrin aldehyde	µg/kg dw	0/65	nd	0.6 – 9,600	nd	100						
Endrin ketone	µg/kg dw	0/65	nd	0.6 – 9,600	nd	100						
Heptachlor	µg/kg dw	0/65	nd	0.6 – 4,800	nd	70	110		2×10^{-5}	31,000		0.08
Heptachlor epoxide	µg/kg dw	0/65	nd	0.6 – 4,800	nd	80	53		5×10^{-5}	790		3.0
Methoxychlor	µg/kg dw	0/65	nd	0.6 – 48,000	nd	700				310,000		0.08
Toxaphene	µg/kg dw	0/65	nd	97 – 480,000	nd	13,000	440		5×10^{-4}			
VOCs												
1,1,1,2-Tetrachloroethane	µg/kg dw	0/49	nd	0.9 – 1,100	nd	20	1,900		3×10^{-7}	2,300,000		0.0002
1,1,1-Trichloroethane	µg/kg dw	1/62	170	0.9 – 1,100	170	20				8,700,000	0.00002	
1,1,2,2-Tetrachloroethane	µg/kg dw	0/60	nd	0.9 – 1,100	nd	20	560		1×10^{-6}	310,000		0.002
1,1,2-Trichloroethane	µg/kg dw	2/62	1.5 J – 41	0.9 – 1,100	21	20	1,100	4×10^{-8}		310,000	0.00013	
1,1,2-Trichlorotrifluoroethane	µg/kg dw	0/62	nd	1.8 – 2,200	nd	36				43,000,000		0.00003
1,1-Dichloroethane	µg/kg dw	3/62	1.1 – 680	0.9 – 1,100	230	30	3,300	2×10^{-7}		16,000,000	0.00004	
1,1-Dichloroethene	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20				240,000		0.002
1,1-Dichloropropene	µg/kg dw	0/49	nd	0.9 – 1,100	nd	20						
1,2,3-Trichlorobenzene	µg/kg dw	0/47	nd	4.4 – 5,600	nd	100						
1,2,3-Trichloropropane	µg/kg dw	0/47	nd	1.8 – 2,200	nd	48	5		2×10^{-4}	5,200		0.2
1,2,4-Trimethylbenzene	µg/kg dw	23/49	1.9 J – 40,000	0.9 – 7.1	5,000	2,000				62,000	0.6	
1,2-Dibromo-3-chloropropane	µg/kg dw	0/62	nd	4.4 – 5,600	nd	90	5.4		5×10^{-4}	4,900		0.6
1,2-Dibromoethane (EDB)	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	34		2×10^{-5}	78,000		0.007
1,2-Dichloroethane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	430		1×10^{-6}	1,400,000		0.0004
1,2-Dichloroethene (total)	µg/kg dw	0/13	nd	2.2 – 4.7	nd	1.4				150,000		0.00002

Table 2. Comparison of Facility Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
1,2-Dichloropropane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	890		6×10^{-7}	16,000		0.03
1,3,5-Trimethylbenzene	µg/kg dw	18/49	1.5 – 12,000	0.9 – 120	1,000	400				780,000	0.02	
1,3-Dichloropropane	µg/kg dw	0/49	nd	0.9 – 1,100	nd	20				1,600,000		0.0003
2,2-Dichloropropane	µg/kg dw	0/49	nd	0.9 – 1,100	nd	20						
2-Chlorotoluene	µg/kg dw	0/47	nd	0.9 – 1,100	nd	20				1,600,000		0.0003
2-Hexanone	µg/kg dw	0/62	nd	4.4 – 5,600	nd	90						
4-Chlorotoluene	µg/kg dw	0/47	nd	0.9 – 1,100	nd	20				5,500,000		0.0001
Acetone	µg/kg dw	44/62	11 – 800	5.6 – 5,600	140	200				61,000,000	0.00001	
Benzene	µg/kg dw	22/62	1.1 – 6,400	0.9 – 810	310	100	1,100	6×10^{-6}		86,000	0.07	
Bromobenzene	µg/kg dw	0/47	nd	0.9 – 1,100	nd	20				300,000		0.002
Bromochloromethane	µg/kg dw	0/49	nd	0.9 – 1,100	nd	20						
Bromodichloromethane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	270		2×10^{-6}	1600000		0.0003
Bromoform	µg/kg dw	0/60	nd	0.9 – 1,100	nd	20	61,000		9×10^{-9}	1,200,000		0.0005
Bromomethane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20				7,300		0.08
Carbon disulfide	µg/kg dw	21/62	1.4 – 460	0.9 – 1,100	25	30				820,000	0.0006	
Carbon tetrachloride	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	610		9×10^{-7}	110,000		0.005
Chlorobenzene	µg/kg dw	7/62	1.2 JN – 320	0.9 – 1,100	110	30				290,000	0.0011	
Chloroethane	µg/kg dw	1/62	2.9	0.9 – 1,100	2.9	20						
Chloroform	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	290		2×10^{-6}	210,000		0.003
Chloromethane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20				120,000		0.005
cis-1,2-Dichloroethene	µg/kg dw	3/62	1.6 J – 130,000	0.9 – 1,100	43,000	2,000				780,000	0.2	
cis-1,3-Dichloropropene	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	1,700		3×10^{-7}	74,000		0.007
Cyclohexane	µg/kg dw	3/13	1.3 J – 31.6 J	2.2 – 3.5	17	4.9				7,000,000	0.000005	
p-Cymene	µg/kg dw	17/49	1.3 J – 11,000 J	0.9 – 83	1,000	300						
Dibromochloromethane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20	680		8×10^{-7}	1,200,000		0.0005
Dibromomethane	µg/kg dw	0/49	nd	0.9 – 1,100	nd	20				25,000		0.02
Dichlorodifluoromethane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20				180,000		0.003
Dichloromethane	µg/kg dw	17/62	2.0 – 370	1.9 – 2,200	46	51						
Ethylbenzene	µg/kg dw	18/62	2.0 J – 26,000	0.9 – 120	2,100	600	5,400	5×10^{-6}		3,500,000	0.007	
Isopropylbenzene	µg/kg dw	19/60	1.3 – 2,300	0.9 – 120	310	100						
Methyl acetate	µg/kg dw	0/13	nd	11.1 – 23.3	nd	6.94				78,000,000		0.0000001
Methyl ethyl ketone	µg/kg dw	31/62	7.6 – 110 J	4.9 – 5,600	33	100						
Methyl isobutyl ketone	µg/kg dw	2/62	5.2 J – 18	4.4 – 5,600	12	90						

Table 2. Comparison of Facility Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
Methylcyclohexane	µg/kg dw	5/13	3.7 – 185 J	2.2 – 3.5	60	20						
n-Butylbenzene	µg/kg dw	19/49	1.4 J – 12,000	0.9 – 83	1,000	400						
n-Propylbenzene	µg/kg dw	19/48	1.3 – 6,700	0.9 – 120	760	300						
sec-Butylbenzene	µg/kg dw	11/47	1.2 – 2,000	0.9 – 1,100	350	100						
Styrene	µg/kg dw	1/62	1.9	0.9 – 1,100	1.9	20				6,300,000	0.0000003	
tert-Butyl methyl ether	µg/kg dw	3/62	2.2 – 6.9	0.9 – 1,100	4.6	20	43,000	2×10^{-10}		17,000,000	0.0000004	
tert-Butylbenzene	µg/kg dw	0/47	nd	0.9 – 1,100	nd	20						
Tetrachloroethene	µg/kg dw	5/62	1.9 – 10.8 J	0.9 – 1,100	4.9	20	550	2×10^{-8}		370,000	0.00003	
Toluene	µg/kg dw	29/62	1.2 – 49,000	0.9 – 810	2,000	900				5,000,000	0.01	
trans-1,2-Dichloroethene	µg/kg dw	1/49	5,500	0.9 – 1,100	5,500	100						
trans-1,3-Dichloropropene	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20						
Trichloroethene	µg/kg dw	6/62	1.5 – 2,400	0.9 – 1,100	400	60	2,800	9×10^{-7}				
Trichlorofluoromethane	µg/kg dw	0/62	nd	0.9 – 1,100	nd	20				790,000		0.0007
Vinyl acetate	µg/kg dw	0/48	nd	4.4 – 5,600	nd	100				970,000		0.003
Vinyl chloride	µg/kg dw	1/62	1,200	0.9 – 1,100	1,200	40	60	2×10^{-5}		74,000	0.02	
o-Xylene	µg/kg dw	25/62	1.6 – 33,000	0.9 – 83	2,000	700				3,800,000	0.009	
m,p-Xylene	µg/kg dw	26/62	1.5 – 120,000 J	0.9 – 83	5,400	2,000				3,400,000	0.04	
Total xylenes	µg/kg dw	28/62	1.8 J – 150,000 J	0.9 – 83	6,000	3,000				630,000	0.2	
Petroleum												
TPH – gasoline range	mg/kg dw	28/51	5.3 – 3,800	5.6 – 12	390	220						
TPH – diesel range	mg/kg dw	60/61	6.3 – 13,000	29	1,500	1,400						
TPH – motor oil range	mg/kg dw	61/61	37 – 12,000	na	1,900	1,900						
Total Risk								6×10^{-4}	2×10^{-3}		39	8

^a Cancer and non-cancer RSLs are from EPA (2009).

^b Exceedance factors based on half the maximum RL are shown only for chemicals never detected in Facility soil.

BHC – benzene hexachloride

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EDB – ethylene dibromide

EPA – US Environmental Protection Agency

HQ – hazard quotient

J – estimated concentration

N – tentative identification

na – not applicable

nd – not detected

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

Bold indicates excess cancer risks greater than 1×10^{-6} or non-cancer HQs greater than 1.

Table 3. Comparison of Wetland Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
Metals												
Aluminum	mg/kg dw	5/5	5,990 – 12,100	na	9,500	9,500				77,000	0.2	
Antimony	mg/kg dw	7/62	0.7 J – 8.4 J	0.3 – 4.5	2	0.6				31	0.3	
Arsenic	mg/kg dw	62/62	1.5 – 53.1	na	9	9	0.39	1 × 10 ⁻⁴		22	2.4	
Barium	mg/kg dw	62/62	64.5 – 481	na	190	190				15,000	0.03	
Beryllium	mg/kg dw	5/5	0.36 – 0.544	na	0.5	0.5	1,400	4 × 10 ⁻¹⁰		160	0.003	
Cadmium	mg/kg dw	57/62	0.3 – 4	0.3 – 0.4	1	1	1,800	2 × 10 ⁻⁹		70	0.06	
Calcium	mg/kg dw	5/5	3,960 – 18,500	na	9,100	9,100						
Chromium	mg/kg dw	62/62	6.6 – 149	na	30	30						
Cobalt	mg/kg dw	62/62	3.5 – 34.3	na	10	10	370	9 × 10 ⁻⁸		23	1.5	
Copper	mg/kg dw	62/62	10.3 – 162	na	58	58				3,100	0.05	
Iron	mg/kg dw	5/5	17,400 – 56,500	na	29,500	29,500				55,000	1.0	
Lead	mg/kg dw	62/62	11.9 J – 320	na	70	70				400	0.8	
Magnesium	mg/kg dw	5/5	2,800 – 4,700	na	3,800	3,800						
Manganese	mg/kg dw	5/5	417 – 1,090	na	724	724				1,800	0.6	
Mercury	mg/kg dw	57/62	0.06 J – 0.4	0.07 – 0.26	0.2	0.2				23	0.02	
Nickel	mg/kg dw	62/62	10 – 48	na	20	20	13,000	4 × 10 ⁻⁹		1,500	0.03	
Selenium	mg/kg dw	3/62	0.55 – 1.1	0.1 – 3	0.8	0.5				390	0.003	
Silver	mg/kg dw	5/5	0.55 – 1.5	na	0.90	0.90				390	0.004	
Sodium	mg/kg dw	5/5	311 – 850	na	500	500						
Thallium	mg/kg dw	0/5	nd	0.3 – 0.75	nd	0.3						
Vanadium	mg/kg dw	62/62	16.1 – 148	na	70	70				390	0.4	
Zinc	mg/kg dw	62/62	37 – 748	na	200	200				23,000	0.03	
PAHs												
2-Chloronaphthalene	µg/kg dw	0/19	nd	20 – 1000	nd	110				6,300,000		0.00008
2-Methylnaphthalene	µg/kg dw	57/62	5.0 – 2,880	5 – 277	230	220				310,000	0.009	
Acenaphthene	µg/kg dw	11/62	5.4 – 18	4.7 – 883	12	36				3,400,000	0.000005	
Acenaphthylene	µg/kg dw	27/62	4.8 – 836 J	4.7 – 782	73	55						
Anthracene	µg/kg dw	56/62	4.9 – 1,600	5 – 735	130	130				17,000,000	0.00009	
Benzo(g,h,i)perylene	µg/kg dw	58/62	7.6 – 6,000	72 – 3910	310	340						
Total benzofluoranthenes	µg/kg dw	58/62	35 J – 3,200	389 – 1560	410	420						
Dibenzofuran	µg/kg dw	36/62	4.8 – 781 J	4.7 – 782	77	68						

Table 3. Comparison of Wetland Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
Fluoranthene	µg/kg dw	61/62	10 J – 2,690	277	300	300				2,300,000	0.0012	
Fluorene	µg/kg dw	19/62	5.4 – 417 J	4.7 – 735	60	38				2,300,000	0.0002	
Naphthalene	µg/kg dw	58/62	5.0 – 4,210	5 – 277	230	210	3,600	1×10^{-6}		140,000	0.03	
Phenanthrene	µg/kg dw	61/62	5.4 J – 4,370	277	280	280						
Pyrene	µg/kg dw	61/62	16 J – 4,560	277	400	400				1,700,000	0.003	
cPAHs TEQ	µg/kg dw	60/62	13.7 J – 5,200	625 – 888	387	387	15	3×10^{-4}				
Total PAHs	µg/kg dw	61/62	107 J – 28,190 J	2770	3,000	3,000						
Phthalates												
Bis(2-ethylhexyl)phthalate	µg/kg dw	17/19	14 J – 9,100	195 – 277	920	840	35,000	3×10^{-7}		1,200,000	0.008	
Butyl benzyl phthalate	µg/kg dw	2/19	86 – 3,140 J	20 – 3910	1,600	470	260,000	1×10^{-8}		12,000,000	0.0003	
Diethyl phthalate	µg/kg dw	0/19	nd	20 – 1000	nd	110				49,000,000		0.00001
Dimethyl phthalate	µg/kg dw	0/19	nd	20 – 1770	nd	190						
Di-n-butyl phthalate	µg/kg dw	5/19	22 – 2,400	20 – 883	530	220				6,100,000	0.0004	
Di-n-octyl phthalate	µg/kg dw	0/19	nd	20 – 4420	nd	420						
Other SVOCs												
1,2,4-Trichlorobenzene	µg/kg dw	0/49	nd	3 – 39	nd	6	22,000		9×10^{-10}	62,000		0.0003
1,2-Dichlorobenzene	µg/kg dw	0/49	nd	1.5 – 15	nd	2				1,900,000		0.000004
1,3-Dichlorobenzene	µg/kg dw	0/49	nd	1.5 – 15	nd	2						
1,4-Dichlorobenzene	µg/kg dw	2/49	2.3 J – 19 J	1.5 – 15	11	2	2,400	8×10^{-9}		3,500,000	0.000005	
2,4,5-Trichlorophenol	µg/kg dw	0/19	nd	98 – 5200	nd	570				6,100,000		0.0004
2,4,6-Trichlorophenol	µg/kg dw	0/19	nd	98 – 5200	nd	350	44,000		6×10^{-8}	61,000		0.04
2,4-Dichlorophenol	µg/kg dw	0/19	nd	98 – 5200	nd	270				180,000		0.01
2,4-Dimethylphenol	µg/kg dw	0/19	nd	20 – 1000	nd	110				1,200,000		0.0004
2,4-Dinitrophenol	µg/kg dw	0/18	nd	200 – 17700	nd	2,000				120,000		0.07
2,4-Dinitrotoluene	µg/kg dw	0/19	nd	98 – 5200	nd	350	1,600		2×10^{-6}	120,000		0.02
2,6-Dinitrotoluene	µg/kg dw	0/19	nd	98 – 8830	nd	950				61,000		0.07
2-Chlorophenol	µg/kg dw	0/19	nd	20 – 1000	nd	110				390,000		0.001
2-Methylphenol	µg/kg dw	0/19	nd	20 – 1000	nd	110				3,100,000		0.0002
2-Nitroaniline	µg/kg dw	0/19	nd	98 – 5200	nd	350				610,000		0.004
2-Nitrophenol	µg/kg dw	0/19	nd	98 – 5200	nd	570						
3,3'-Dichlorobenzidine	µg/kg dw	0/17	nd	98 – 5200	nd	630	1,100		2×10^{-6}			
3-Nitroaniline	µg/kg dw	0/19	nd	98 – 5200	nd	570						
4,6-Dinitro-o-cresol	µg/kg dw	0/18	nd	200 – 10000	nd	1,200				4,900		1.0

Table 3. Comparison of Wetland Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
4-Bromophenyl phenyl ether	µg/kg dw	0/19	nd	20 – 1000	nd	110						
4-Chloro-3-methylphenol	µg/kg dw	0/19	nd	98 – 5200	nd	570						
4-Chloroaniline	µg/kg dw	0/18	nd	98 – 5200	nd	360	2,400		1×10^{-6}	240,000		0.01
4-Chlorophenyl phenyl ether	µg/kg dw	0/19	nd	20 – 1000	nd	110						
4-Methylphenol	µg/kg dw	6/19	17 J – 190	20 – 1000	84	140				310,000	0.0006	
4-Nitroaniline	µg/kg dw	0/19	nd	98 – 5200	nd	570	24,000		1×10^{-7}	240,000		0.01
4-Nitrophenol	µg/kg dw	0/19	nd	98 – 8830	nd	950						
Acetophenone	µg/kg dw	1/5	630 J	195 – 782	630	330				7,800,000	0.00008	
Aniline	µg/kg dw	0/13	nd	20 – 1000	nd	54	85,000		6×10^{-9}	430,000		0.001
Atrazine	µg/kg dw	0/5	nd	973 – 4420	nd	1,440	2,100		1×10^{-6}	2,100,000		0.001
Benzaldehyde	µg/kg dw	5/5	59.6 J – 1,080 J	na	470	470				7,800,000	0.00014	
Benzoic acid	µg/kg dw	12/14	120 J – 28,000	590 – 880	2,800	2,400				2.4E+08	0.00012	
Benzyl alcohol	µg/kg dw	7/14	15 J – 2,100	20 – 99	370	190				6,100,000	0.0003	
Biphenyl	µg/kg dw	1/5	836 J	195 – 782	836	366				3,900,000	0.0002	
bis(2-chloroethoxy)methane	µg/kg dw	0/19	nd	20 – 1000	nd	110				180,000		0.003
bis(2-chloroethyl)ether	µg/kg dw	0/19	nd	20 – 1000	nd	110	210		2×10^{-6}			
bis(2-chloroisopropyl)ether	µg/kg dw	0/19	nd	20 – 1000	nd	110	4,600		1×10^{-7}	3,100,000		0.0002
Caprolactam	µg/kg dw	0/5	nd	973 – 4420	nd	1,440				31,000,000		0.00007
Carbazole	µg/kg dw	5/19	12 J – 66 J	20 – 1000	36	120						
Hexachlorobenzene	µg/kg dw	0/62	nd	0.96 – 883	nd	40	300		1×10^{-6}	49,000		0.009
Hexachlorobutadiene	µg/kg dw	0/62	nd	0.96 – 883	nd	38	6,200		7×10^{-8}	61,000		0.007
Hexachlorocyclopentadiene	µg/kg dw	0/18	nd	98 – 5200	nd	600				370,000		0.007
Hexachloroethane	µg/kg dw	0/19	nd	20 – 1000	nd	110	35,000		1×10^{-8}	61,000		0.008
Isophorone	µg/kg dw	0/19	nd	20 – 1000	nd	110	510,000		1×10^{-9}	12,000,000		0.00004
Nitrobenzene	µg/kg dw	0/19	nd	20 – 1000	nd	110	4800		1×10^{-7}	130,000		0.004
n-Nitroso-di-n-propylamine	µg/kg dw	0/19	nd	98 – 5200	nd	270	69		4×10^{-5}			
n-Nitrosodiphenylamine	µg/kg dw	0/19	nd	20 – 1000	nd	120	99,000		5×10^{-9}			
Pentachlorophenol	µg/kg dw	1/19	80 J	98 – 5200	80	580	3,000	3×10^{-8}		1,400,000	0.00006	
Phenol	µg/kg dw	5/19	53 – 498 J	20 – 1000	200	120				18,000,000	0.00003	
PCBs												
Total PCBs	µg/kg dw	38/62	35 – 4,200	32 – 990	500	300	220	2×10^{-5}		1,100	3.8	
Pesticides												
Total DDTs	µg/kg dw	61/62	2.7 J – 46,000	130	3,000	3,000	1700	3×10^{-5}		36,000	1.3	

Table 3. Comparison of Wetland Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
Aldrin	µg/kg dw	0/62	nd	0.92 – 490	nd	17	29		8×10^{-6}	1,800		0.1
Dieldrin	µg/kg dw	0/62	nd	0.97 – 980	nd	33	30		2×10^{-5}	3,100		0.2
alpha-BHC	µg/kg dw	0/62	nd	0.92 – 490	nd	17	77		3×10^{-6}	490,000		0.0005
beta-BHC	µg/kg dw	0/62	nd	0.92 – 490	nd	17	270		9×10^{-7}			
gamma-BHC	µg/kg dw	0/62	nd	0.92 – 490	nd	17	520		5×10^{-7}	21,000		0.01
delta-BHC	µg/kg dw	2/62	3.0	0.92 – 490	3.0	17						
alpha-Chlordane	µg/kg dw	0/62	nd	0.96 – 490	nd	17						
gamma-Chlordane	µg/kg dw	0/62	nd	0.96 – 490	nd	17						
Total chlordane	µg/kg dw	0/62	nd	0.96 – 490	nd	17	1,600		2×10^{-7}	35,000		0.007
alpha-Endosulfan	µg/kg dw	0/62	nd	0.92 – 490	nd	17				370,000		0.0007
beta-Endosulfan	µg/kg dw	0/62	nd	0.92 – 980	nd	33						
Endosulfan sulfate	µg/kg dw	0/62	nd	1.9 – 980	nd	40						
Endrin	µg/kg dw	0/62	nd	0.92 – 980	nd	30				18,000		0.03
Endrin aldehyde	µg/kg dw	0/62	nd	0.97 – 980	nd	34						
Endrin ketone	µg/kg dw	0/62	nd	0.97 – 980	nd	34						
Heptachlor	µg/kg dw	0/62	nd	0.92 – 490	nd	20	110		2×10^{-6}	31,000		0.008
Heptachlor epoxide	µg/kg dw	0/62	nd	0.92 – 490	nd	18	53		5×10^{-6}	790		0.3
Methoxychlor	µg/kg dw	1/62	4.6 J	0.92 – 4900	4.6	200				310,000	0.00001	
Toxaphene	µg/kg dw	0/62	nd	96 – 49000	nd	3,000	440		6×10^{-5}			
VOCs												
1,1,1,2-Tetrachloroethane	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4	1,900		2×10^{-9}	2,300,000		0.000002
1,1,1-Trichloroethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2				8,700,000		0.0000009
1,1,2,2-Tetrachloroethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2	560		1×10^{-8}	310,000		0.00002
1,1,2-Trichloroethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2	1,100		7×10^{-9}	310,000		0.00002
1,1,2-Trichlorotrifluoroethane	µg/kg dw	0/49	nd	3 – 15	nd	3				43,000,000		0.0000002
1,1-Dichloroethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2	3,300		2×10^{-9}	16,000,000		0.0000005
1,1-Dichloroethene	µg/kg dw	0/49	nd	1.5 – 15	nd	2				240,000		0.00003
1,1-Dichloropropene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
1,2,3-Trichlorobenzene	µg/kg dw	0/44	nd	7.5 – 39	nd	6.8						
1,2,3-Trichloropropane	µg/kg dw	0/44	nd	3 – 15	nd	2.7	5		2×10^{-6}	5,200		0.001
1,2,4-Trimethylbenzene	µg/kg dw	4/44	3.6 J – 9.2	1.5 – 7.7	6.8	1.8				62,000	0.0001	
1,2-Dibromo-3-chloropropane	µg/kg dw	0/49	nd	3 – 150	nd	8	5.4		1×10^{-5}	4,900		0.02
1,2-Dibromoethane (EDB)	µg/kg dw	0/49	nd	1.5 – 15	nd	2	34		2×10^{-7}	78,000		0.0001

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Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
1,2-Dichloroethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2	430		2×10^{-8}	1,400,000		0.000005
1,2-Dichloroethene (total)	µg/kg dw	0/5	nd	3 – 15	nd	3				150,000		0.00005
1,2-Dichloropropane	µg/kg dw	0/49	nd	1.5 – 15	nd	2	890		8×10^{-9}	16,000		0.0005
1,3,5-Trimethylbenzene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4				780,000		0.000005
1,3-Dichloropropane	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4				1,600,000		0.000002
2,2-Dichloropropane	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
2-Chlorotoluene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4				1,600,000		0.000002
2-Hexanone	µg/kg dw	0/49	nd	7.5 – 59.8	nd	7.4						
4-Chlorotoluene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4				5,500,000		0.0000007
Acetone	µg/kg dw	44/49	76 – 2,300	61.1 – 299	540	490				61,000,000	0.00004	
Benzene	µg/kg dw	25/49	1.8 – 56	1.6 – 15	10	6	1,100	5×10^{-8}		86,000	0.0007	
Bromobenzene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4				300,000		0.00001
Bromochloromethane	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
Bromodichloromethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2	270		3×10^{-8}	1,600,000		0.000005
Bromoform	µg/kg dw	0/49	nd	1.5 – 15	nd	2	61,000		1×10^{-10}	1,200,000		0.000006
Bromomethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2				7,300		0.001
Carbon disulfide	µg/kg dw	3/49	3.9 – 7.5	1.5 – 59.8	5.7	2.8				820,000	0.000009	
Carbon tetrachloride	µg/kg dw	0/49	nd	1.5 – 15	nd	2	610		1×10^{-8}	110,000		0.00007
Chlorobenzene	µg/kg dw	0/49	nd	1.5 – 15	nd	2				290,000		0.00003
Chloroethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2						
Chloroform	µg/kg dw	0/49	nd	1.5 – 15	nd	2	290		3×10^{-8}	210,000		0.00004
Chloromethane	µg/kg dw	0/49	nd	1.5 – 29.9	nd	1.9				120,000		0.0001
cis-1,2-Dichloroethene	µg/kg dw	4/49	1.9 – 9.7	1.5 – 15	4.8	2				780,000	0.00001	
cis-1,3-Dichloropropene	µg/kg dw	0/49	nd	1.5 – 15	nd	2	1,700		4×10^{-9}	74,000		0.0001
Cyclohexane	µg/kg dw	0/5	nd	3 – 15	nd	3				7,000,000		0.000001
p-Cymene	µg/kg dw	3/44	3.4 J – 72 J	1.5 – 7.7	28	3.2						
Dibromochloromethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2	680		1×10^{-8}	1,200,000		0.000006
Dibromomethane	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4				25,000		0.0002
Dichlorodifluoromethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2				180,000		0.00004
Dichloromethane	µg/kg dw	4/49	4.1 – 5.3	3 – 58.7	4.6	3.9						
Ethylbenzene	µg/kg dw	2/49	3.0 – 3.4	1.5 – 15	3.2	2	5,400	6×10^{-10}		3,500,000	0.000001	
Isopropylbenzene	µg/kg dw	0/49	nd	1.5 – 15	nd	2						
Methyl acetate	µg/kg dw	0/5	nd	15.3 – 74.8	nd	16.1				78,000,000		0.0000005

Table 3. Comparison of Wetland Soil Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Residential RSL			Non-Cancer Residential RSL		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b
Methyl ethyl ketone	µg/kg dw	42/49	9.7 – 260	9 – 150	61	55						
Methyl isobutyl ketone	µg/kg dw	2/49	15 – 16	7.5 – 59.8	16	7.7						
Methylcyclohexane	µg/kg dw	0/5	nd	3 – 15	nd	3						
n-Butylbenzene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
n-Propylbenzene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
sec-Butylbenzene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
Styrene	µg/kg dw	0/49	nd	1.5 – 15	nd	2				6,300,000		0.000001
tert-Butyl methyl ether	µg/kg dw	0/49	nd	1.5 – 15	nd	2	43,000		2×10^{-10}	17,000,000		0.0000004
tert-Butylbenzene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
Tetrachloroethene	µg/kg dw	2/49	5.1 – 30	1.5 – 15	18	2	550	5×10^{-8}		370,000	0.00008	
Toluene	µg/kg dw	36/49	1.8 – 68	1.6 – 15	14	10				5,000,000	0.00001	
trans-1,2-Dichloroethene	µg/kg dw	0/44	nd	1.5 – 7.7	nd	1.4						
trans-1,3-Dichloropropene	µg/kg dw	0/49	nd	1.5 – 15	nd	2						
Trichloroethene	µg/kg dw	3/49	2.4 – 4.7	1.5 – 15	3.3	2	2,800	2×10^{-9}				
Trichlorofluoromethane	µg/kg dw	0/49	nd	1.5 – 15	nd	2				790,000		0.000009
Vinyl acetate	µg/kg dw	0/43	nd	7.5 – 39	nd	6.9				970,000		0.00002
Vinyl chloride	µg/kg dw	0/49	nd	1.5 – 15	nd	2	60		1×10^{-7}	74,000		0.0001
o-Xylene	µg/kg dw	2/49	4.4 – 5.2	1.5 – 15	4.8	2				3,800,000	0.000001	
m,p-Xylene	µg/kg dw	6/49	2.0 J – 11	1.5 – 29.9	4.5	2.3				3,400,000	0.000003	
Total xylenes	µg/kg dw	6/49	2.0 J – 15	1.5 – 29.9	6.0	2.5				630,000	0.00002	
Petroleum												
TPH – gasoline range	mg/kg dw	2/57	19 – 20	8.4 – 58	20	10						
TPH – diesel range	mg/kg dw	55/61	8.4 – 4,000	7.4 – 10	400	360						
TPH – motor oil range	mg/kg dw	57/61	28 – 6,600	15 – 17	1,100	1,000						
Total Risk								5×10^{-4}	2×10^{-4}		13	2

^a Cancer and non-cancer RSLs are from EPA (2009).

^b Exceedance factors based on half the maximum RL are shown only for chemicals never detected in wetland soil.

BHC – benzene hexachloride

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EDB – ethylene dibromide

EPA – US Environmental Protection Agency

Bold indicates excess cancer risks greater than 1×10^{-6} or non-cancer HQs greater than 1.

HQ – hazard quotient

J – estimated concentration

na – not applicable

nd – not detected

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
Metals (dissolved)															
Antimony	µg/L	5/22	0.2 – 0.6	0.2	0.3	0.1				15	0.04		6	0.1	
Arsenic	µg/L	22/22	0.8 – 32.2	na	10	10	0.045	7 × 10 ⁻⁴		11	2.9		10	3.2	
Barium	µg/L	22/22	65 – 389	na	190	190				7,300	0.05		2,000	0.2	
Cadmium	µg/L	0/22	nd	0.2	nd	0.1									
Chromium	µg/L	0/22	nd	5	nd	3									
Cobalt	µg/L	9/22	3 – 25	3	9	5				11	2.3				
Copper	µg/L	2/22	3 – 5	2	4	1				1,500	0.003		1,300	0.004	
Iron	µg/L	22/22	1,720 – 64,400	na	29,000	29,000				26,000	2.5				
Lead	µg/L	0/22	nd	1	nd	0.5							15		0.03
Manganese	µg/L	22/22	724 – 6,510	na	3,100	3,100				880	7.4				
Mercury	µg/L	0/22	nd	0.1	nd	0.05				11		0.005	2		0.03
Nickel	µg/L	5/22	10 – 20	10	10	7				730	0.03				
Selenium	µg/L	8/22	0.5 – 1.2	0.5 – 2	0.7	0.7				180	0.007		50	0.02	
Vanadium	µg/L	5/22	3 – 9	3	5	3				180	0.05				
Zinc	µg/L	2/22	40 – 80	10	60	10				11,000	0.007				
Metals (total)															
Aluminum	µg/L	6/6	193 – 5,890	na	1,330	1,330				37,000	0.2				
Antimony	µg/L	2/28	0.2 – 0.5	0.2 – 1.6	0.4	0.3				15	0.03		6	0.08	
Arsenic	µg/L	28/28	1 – 31.6	na	10	10	0.045	7 × 10 ⁻⁴		11	2.9		10	3.2	
Barium	µg/L	28/28	65 – 497	na	230	230				7,300	0.07		2,000	0.2	
Beryllium	µg/L	1/6	1.5	1	1.5	0.7				73	0.02		4	0.4	
Cadmium	µg/L	4/28	0.3 – 1.31	0.2	0.7	0.2									
Chromium	µg/L	4/28	6 J – 8.1	5	7	4									
Cobalt	µg/L	9/28	3 – 23	3 – 5	9	4				11	2.1				
Copper	µg/L	8/28	2 – 25.1	2 – 4	8	3				1,500	0.02		1,300	0.02	
Iron	µg/L	28/28	3,130 – 65,700	na	31,000	31,000				26,000	2.5				
Lead	µg/L	8/28	0.36 – 19.6	1	5	2							15	1.3	

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
Magnesium	µg/L	6/6	24,900 – 95,800	na	45,700	45,700									
Manganese	µg/L	28/28	667 – 7,860	na	3,400	3,400				880	8.9				
Mercury	µg/L	1/28	0.14	0.1	0.14	0.05				11	0.01		2	0.07	
Nickel	µg/L	8/28	10 – 25	10	20	8				730	0.03				
Selenium	µg/L	10/28	0.5 – 4.7	0.5 – 2	1	1				180	0.03		50	0.09	
Silver	µg/L	1/6	1	1	1	0.6				180	0.006				
Thallium	µg/L	6/6	0.00894 – 0.0527	na	0.0242	0.0242							2	0.03	
Vanadium	µg/L	14/28	3 – 54.4	3	10	7				180	0.3				
Zinc	µg/L	10/28	8.7 – 1,180	4 – 10	200	60				11,000	0.1				
PAHs															
2-Chloronaphthalene	µg/L	0/6	nd	0.37 – 0.4	nd	0.2				2,900		0.00007			
2-Methylnaphthalene	µg/L	7/28	0.1 J – 1.8	0.1 – 0.38	0.7	0.2				150	0.01				
Acenaphthene	µg/L	11/28	0.14 – 3.2	0.1 – 0.4	0.99	0.4				2,200	0.001				
Acenaphthylene	µg/L	0/28	nd	0.1 – 0.4	nd	0.08									
Anthracene	µg/L	5/28	0.10 – 0.24	0.1 – 0.4	0.17	0.1				11,000	0.00002				
Benzo(g,h,i)perylene	µg/L	0/28	nd	0.1 – 2	nd	0.2									
Dibenzofuran	µg/L	2/28	0.16 – 0.18	0.1 – 0.4	0.17	0.09									
Fluoranthene	µg/L	3/28	0.12 – 0.64	0.1 – 0.4	0.30	0.1				1,500	0.0004				
Fluorene	µg/L	9/28	0.13 – 1.9	0.1 – 0.4	0.48	0.2				1,500	0.001				
Naphthalene	µg/L	7/28	0.10 – 1.5	0.1 – 0.4	0.47	0.2	0.14	1×10^{-5}		6.2	0.2				
Phenanthrene	µg/L	3/28	0.13 – 0.25	0.1 – 0.4	0.18	0.09									
Pyrene	µg/L	3/28	0.12 – 0.53	0.1 – 0.4	0.26	0.09				1,100	0.0005				
cPAHs TEQ	µg/L	0/28	nd	0.091 – 1.5	nd	0.186	0.0029		3×10^{-4}				0.2		3.8
Phthalates															
Bis(2-ethylhexyl)phthalate	µg/L	5/6	0.59 – 1.8	0.38	1.2	1.0	4.8	4×10^{-7}		730	0.002		6	0.3	
Butyl benzyl phthalate	µg/L	0/6	nd	1.8 – 2	nd	0.9	35		3×10^{-8}	7,300		0.0001			
Diethyl phthalate	µg/L	1/6	0.25 J	0.37 – 0.4	0.25	0.2				29,000	0.000009				
Dimethyl phthalate	µg/L	0/6	nd	0.74 – 0.8	nd	0.4									
Di-n-butyl phthalate	µg/L	2/6	0.1 J – 0.15 J	0.37 – 0.4	0.1	0.2				3,700	0.00004				
Di-n-octyl phthalate	µg/L	0/6	nd	1.8 – 2	nd	0.9									

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
Other SVOCs															
1,2,4-Trichlorobenzene	µg/L	0/28	nd	0.5 – 5	nd	2	2.3		1 × 10 ⁻⁶	4.1		0.6	70		0.04
1,2-Dichlorobenzene	µg/L	2/28	0.22 J – 0.50	0.2 – 1	0.36	0.5				370	0.001		600	0.0008	
1,3-Dichlorobenzene	µg/L	2/28	0.2 J – 0.35 J	0.2 – 1	0.3	0.4									
1,4-Dichlorobenzene	µg/L	4/28	0.18 J – 1.4	0.2 – 1	0.8	0.5	0.43	3 × 10 ⁻⁶		1,000	0.001		75	0.02	
2,4,5-Trichlorophenol	µg/L	0/6	nd	1.8 – 2	nd	0.9				3,700		0.0003			
2,4,6-Trichlorophenol	µg/L	0/6	nd	0.74 – 0.8	nd	0.4	6.1	7 × 10 ⁻⁸		37		0.01			
2,4-Dichlorophenol	µg/L	0/6	nd	0.37 – 0.4	nd	0.2				110		0.002			
2,4-Dimethylphenol	µg/L	0/6	nd	0.37 – 0.4	nd	0.2				730		0.0003			
2,4-Dinitrophenol	µg/L	0/6	nd	7.4 – 8	nd	4				73		0.05			
2,4-Dinitrotoluene	µg/L	0/6	nd	0.74 – 0.8	nd	0.4	0.22	2 × 10 ⁻⁶		73		0.005			
2,6-Dinitrotoluene	µg/L	0/6	nd	3.7 – 4	nd	2				37		0.05			
2-Chlorophenol	µg/L	1/6	0.97	0.37 – 0.38	0.97	0.32				180	0.005				
2-Methylphenol	µg/L	0/6	nd	0.37 – 0.4	nd	0.2				1,800		0.0001			
2-Nitroaniline	µg/L	0/6	nd	0.74 – 0.8	nd	0.4				370		0.001			
2-Nitrophenol	µg/L	0/6	nd	1.8 – 2	nd	0.9									
3,3'-Dichlorobenzidine	µg/L	0/6	nd	1.8 – 2	nd	0.9	0.15	7 × 10 ⁻⁶							
3-Nitroaniline	µg/L	0/6	nd	1.8 – 2	nd	0.9									
4,6-Dinitro-o-cresol	µg/L	0/6	nd	3.7 – 4	nd	2				2.9		0.7			
4-Bromophenyl phenyl ether	µg/L	0/6	nd	0.37 – 0.4	nd	0.2									
4-Chloro-3-methylphenol	µg/L	0/6	nd	1.8 – 2	nd	0.9									
4-Chloroaniline	µg/L	0/6	nd	0.74 – 0.8	nd	0.4	0.34	1 × 10 ⁻⁶		150		0.003			
4-Chlorophenyl phenyl ether	µg/L	0/6	nd	0.37 – 0.4	nd	0.2									
4-Methylphenol	µg/L	0/6	nd	0.37 – 0.4	nd	0.2				180		0.001			
4-Nitroaniline	µg/L	0/6	nd	1.8 – 2	nd	0.9	3.4	3 × 10 ⁻⁷		150		0.007			
4-Nitrophenol	µg/L	0/6	nd	3.7 – 4	nd	2									
Acetophenone	µg/L	1/6	0.16 J	0.37 – 0.38	0.16	0.19				3,700	0.00004				
Atrazine	µg/L	0/6	nd	1.8 – 2	nd	0.9	0.29	3 × 10 ⁻⁶		1,300		0.0008	3		0.3
Benzaldehyde	µg/L	2/6	0.12 J – 0.13 J	0.37 – 0.4	0.13	0.2				3,700	0.00004				
Biphenyl	µg/L	0/6	nd	0.37 – 0.4	nd	0.2				1,800		0.0001			

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
bis(2-chloroethoxy)methane	µg/L	0/6	nd	0.37 – 119	nd	10				110		0.5			
bis(2-chloroethyl)ether	µg/L	0/6	nd	0.37 – 0.4	nd	0.2	0.012		2×10^{-5}						
bis(2-chloroisopropyl)ether	µg/L	0/6	nd	0.37 – 0.4	nd	0.2	0.32		6×10^{-7}	1,500		0.0001			
Caprolactam	µg/L	0/6	nd	1.8 – 2	nd	0.9				18,000		0.00006			
Carbazole	µg/L	0/6	nd	0.37 – 0.4	nd	0.2									
Hexachlorobenzene	µg/L	0/4	nd	0.005	nd	0.0025	0.042		6×10^{-8}	29		0.00009	1		0.003
Hexachlorobenzene	µg/L	0/28	nd	0.005 – 0.4	nd	0.04	0.042		5×10^{-6}	29		0.007	1		0.2
Hexachlorobutadiene	µg/L	0/4	nd	0.005	nd	0.0025	0.86		3×10^{-9}	37		0.00007			
Hexachlorobutadiene	µg/L	0/28	nd	0.005 – 0.4	nd	0.04	0.86		2×10^{-7}	37		0.005			
Hexachlorocyclopentadiene	µg/L	0/6	nd	1.8 – 2	nd	0.9				220		0.005	50		0.02
Hexachloroethane	µg/L	0/6	nd	0.37 – 0.4	nd	0.2	4.8		4×10^{-8}	37		0.005			
Isophorone	µg/L	0/6	nd	0.37 – 0.4	nd	0.2	71		3×10^{-9}	7,300		0.00003			
Nitrobenzene	µg/L	0/6	nd	0.37 – 0.4	nd	0.2	0.12		2×10^{-6}	15		0.01			
n-Nitroso-di-n-propylamine	µg/L	0/6	nd	0.37 – 0.4	nd	0.2	0.0096		2×10^{-5}						
n-Nitrosodiphenylamine	µg/L	0/6	nd	0.37 – 0.4	nd	0.2	14		1×10^{-8}						
Pentachlorophenol	µg/L	0/6	nd	1.8 – 2	nd	0.9	0.56		2×10^{-6}	1,100		0.0009	1		1.0
Phenol	µg/L	5/6	0.095 J – 0.37 J	0.38	0.18	0.19				11,000	0.00003				
PCBs															
Total PCBs	µg/L	0/28	nd	0.1 – 0.96	nd	0.14	0.034		1×10^{-5}	0.73		0.7			
Pesticides (normal)															
Total DDTs	µg/L	12/28	0.0071 J – 0.24 J	0.01 – 0.019	0.063	0.030	0.2	1×10^{-6}		18	0.01				
Aldrin	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039	0.004		2×10^{-6}	1.1		0.009			
Dieldrin	µg/L	0/28	nd	0.01 – 0.019	nd	0.0059	0.0042		2×10^{-6}	1.8		0.005			
Total aldrin/dieldrin	µg/L	0/28	nd	0.01 – 0.019	nd	0.0059									
alpha-BHC	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039	0.011		9×10^{-7}	290		0.00003			
beta-BHC	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039	0.037		3×10^{-7}						
gamma-BHC	µg/L	0/28	nd	0.005 – 0.019	nd	0.0042	0.061		2×10^{-7}	11		0.0009	0.2		0.05
delta-BHC	µg/L	0/28	nd	0.005 – 0.043	nd	0.0046									
alpha-Chlordane	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039									
gamma-Chlordane	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039									

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
Total chlordane	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039	0.19		5×10^{-8}	18		0.0005	2		0.005
alpha-Endosulfan	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039				220		0.00004			
beta-Endosulfan	µg/L	0/28	nd	0.01 – 0.019	nd	0.0059									
Endosulfan sulfate	µg/L	0/28	nd	0.01 – 0.019	nd	0.0059									
Endrin	µg/L	0/28	nd	0.01 – 0.019	nd	0.0059				11		0.0009	2		0.005
Endrin aldehyde	µg/L	0/28	nd	0.01 – 0.019	nd	0.0059									
Endrin ketone	µg/L	0/28	nd	0.01 – 0.019	nd	0.0059									
Heptachlor	µg/L	0/28	nd	0.005 – 0.024	nd	0.0043	0.015		8×10^{-7}	18		0.0007	0.4		0.03
Heptachlor epoxide	µg/L	0/28	nd	0.005 – 0.019	nd	0.0039	0.0074		1×10^{-6}	0.47		0.02	0.2		0.05
Methoxychlor	µg/L	0/28	nd	0.018 – 0.05	nd	0.022				180		0.0001	40		0.0006
Toxaphene	µg/L	0/28	nd	0.5 – 4.8	nd	0.69	0.061		4×10^{-5}				3		0.8
Pesticides (dissolved)															
Total DDTs	µg/L	2/4	0.011 – 0.073 J	0.01	0.042	0.024	0.2	4×10^{-7}		18	0.004				
Aldrin	µg/L	0/4	nd	0.005	nd	0.0025	0.004		6×10^{-7}	1.1		0.002			
Dieldrin	µg/L	0/4	nd	0.01	nd	0.0050	0.0042		1×10^{-6}	1.8		0.003			
Total aldrin/dieldrin	µg/L	0/4	nd	0.01	nd	0.0050									
alpha-BHC	µg/L	0/4	nd	0.005	nd	0.0025	0.011		2×10^{-7}	290		0.000009			
beta-BHC	µg/L	0/4	nd	0.005	nd	0.0025	0.037		7×10^{-8}						
gamma-BHC	µg/L	0/4	nd	0.005	nd	0.0025	0.061		4×10^{-8}	11		0.0002	0.2		0.01
delta-BHC	µg/L	0/4	nd	0.005	nd	0.0025									
alpha-Chlordane	µg/L	0/4	nd	0.005	nd	0.0025									
gamma-Chlordane	µg/L	0/4	nd	0.005	nd	0.0025									
Total chlordane	µg/L	0/4	nd	0.005	nd	0.0025	0.19		1×10^{-8}	18		0.0001	2		0.001
alpha-Endosulfan	µg/L	0/4	nd	0.005	nd	0.0025				220		0.00001			
beta-Endosulfan	µg/L	0/4	nd	0.01	nd	0.0050									
Endosulfan sulfate	µg/L	0/4	nd	0.01	nd	0.0050									
Endrin	µg/L	0/4	nd	0.01	nd	0.0050				11		0.0005	2		0.003
Endrin aldehyde	µg/L	0/4	nd	0.01	nd	0.0050									
Endrin ketone	µg/L	0/4	nd	0.01	nd	0.0050									
Heptachlor	µg/L	0/4	nd	0.005	nd	0.0025	0.015		2×10^{-7}	18		0.0001	0.4		0.006

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
Heptachlor epoxide	µg/L	0/4	nd	0.005	nd	0.0025	0.0074		3×10^{-7}	0.47		0.005	0.2		0.01
Methoxychlor	µg/L	0/4	nd	0.05	nd	0.025				180		0.0001	40		0.0006
Toxaphene	µg/L	0/4	nd	0.5	nd	0.25	0.061		4×10^{-6}				3		0.08
VOCs															
1,1,1,2-Tetrachloroethane	µg/L	0/22	nd	0.2 – 1	nd	0.45	0.52		1×10^{-6}	1,100		0.0005			
1,1,1-Trichloroethane	µg/L	0/28	nd	0.2 – 1	nd	0.5				9,100		0.00005	200		0.003
1,1,2,2-Tetrachloroethane	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.067		7×10^{-6}	150		0.003			
1,1,2-Trichloroethane	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.24		2×10^{-6}	150		0.003	5		0.1
1,1,2-Trichlorotrifluoroethane	µg/L	0/28	nd	0.2 – 2	nd	0.8				59,000		0.00002			
1,1-Dichloroethane	µg/L	0/28	nd	0.2 – 1	nd	0.5	2.4		2×10^{-7}	7,300		0.00007			
1,1-Dichloroethene	µg/L	0/28	nd	0.2 – 1	nd	0.5				340		0.001	7		0.07
1,1-Dichloropropene	µg/L	0/22	nd	0.2 – 1	nd	0.45									
1,2,3-Trichlorobenzene	µg/L	0/22	nd	0.5 – 5	nd	2.2									
1,2,3-Trichloropropane	µg/L	0/22	nd	0.5 – 2	nd	0.90	0.00072		1×10^{-3}	0.62		1.6			
1,2,4-Trimethylbenzene	µg/L	2/22	3.7 – 7.2	0.2 – 1	5.5	0.91				15	0.5				
1,2-Dibromo-3-chloropropane	µg/L	0/28	nd	0.5 – 5	nd	2	0.00032		8×10^{-3}	0.39		6.4	0.2		13
1,2-Dibromoethane (EDB)	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.0065		8×10^{-5}	18		0.03	0.05		10
1,2-Dichloroethane	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.15		3×10^{-6}	640		0.0008	5		0.1
1,2-Dichloroethene (total)	µg/L	0/6	nd	1	nd	0.5				110		0.005	100		0.005
1,2-Dichloropropane	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.39		1×10^{-6}	8.3		0.06	5		0.1
1,3,5-Trimethylbenzene	µg/L	3/22	1.5 – 3.0	0.2 – 1	2.3	0.71				370	0.008				
1,3-Dichloropropane	µg/L	0/22	nd	0.2 – 5	nd	1.2				730		0.003			
2,2-Dichloropropane	µg/L	0/22	nd	0.2 – 1	nd	0.45									
2-Chlorotoluene	µg/L	0/22	nd	0.2 – 1	nd	0.45				730		0.0007			
2-Hexanone	µg/L	0/28	nd	2 – 5	nd	2									
4-Chlorotoluene	µg/L	0/22	nd	0.2 – 1	nd	0.45				2,600		0.0002			
Acetone	µg/L	11/28	4.4 – 18	2 – 15.6	9.3	6				22,000	0.0008				
Benzene	µg/L	8/28	0.80 – 140	0.2 – 6.2	20	6	0.41	3×10^{-4}		44	3.2		5	28	
Bromobenzene	µg/L	0/22	nd	0.2 – 1	nd	0.45				88		0.006			
Bromochloromethane	µg/L	0/22	nd	0.2 – 1	nd	0.45									

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
Bromodichloromethane	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.12		4×10^{-6}	730		0.0007	80		0.006
Bromoform	µg/L	0/28	nd	0.2 – 1	nd	0.5	8.5		6×10^{-8}	730		0.0007	80		0.006
Bromomethane	µg/L	0/28	nd	0.5 – 1	nd	0.5				8.7		0.06			
Carbon disulfide	µg/L	0/28	nd	0.2 – 2	nd	0.6				1,000		0.001			
Carbon tetrachloride	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.44		1×10^{-6}	86		0.006	5		0.1
Chlorobenzene	µg/L	15/28	0.20 – 130	0.2 – 1	30	10				91	1.4		100	1.3	
Chloroethane	µg/L	0/28	nd	0.2 – 2	nd	0.6									
Chloroform	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.19		3×10^{-6}	130		0.004	80		0.006
Chloromethane	µg/L	0/28	nd	0.2 – 1	nd	0.5				190		0.003			
cis-1,2-Dichloroethene	µg/L	1/28	0.23 J	0.2 – 1	0.23	0.4				370	0.0006		70	0.003	
cis-1,3-Dichloropropene	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.43		1×10^{-6}	40		0.01			
Cyclohexane	µg/L	0/6	nd	1	nd	0.5				13,000		0.00004			
p-Cymene	µg/L	1/22	0.30	0.2 – 1	0.30	0.45									
Dibromochloromethane	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.15		3×10^{-6}	730		0.0007	80		0.006
Dibromomethane	µg/L	0/22	nd	0.2 – 1	nd	0.45				8.2		0.06			
Dichlorodifluoromethane	µg/L	0/28	nd	0.2 – 1	nd	0.5				390		0.001			
Dichloromethane	µg/L	0/28	nd	0.5 – 2	nd	0.8									
Ethylbenzene	µg/L	1/28	1.2	0.2 – 1	1.2	0.5	1.5	8×10^{-7}		1,300	0.0009		700	0.002	
Isopropylbenzene	µg/L	4/28	0.039 J – 8.3	0.2 – 1	3.7	0.9									
Methyl acetate	µg/L	0/6	nd	1	nd	0.5				37,000		0.00001			
Methyl ethyl ketone	µg/L	0/28	nd	2 – 5	nd	2									
Methyl isobutyl ketone	µg/L	0/28	nd	2 – 5	nd	2									
Methylcyclohexane	µg/L	0/6	nd	1	nd	0.5									
n-Butylbenzene	µg/L	1/22	0.50	0.2 – 1	0.50	0.46									
n-Propylbenzene	µg/L	4/22	1.8 – 11	0.2 – 1	5.3	1.3									
sec-Butylbenzene	µg/L	1/22	0.40	0.2 – 1	0.40	0.46									
Styrene	µg/L	1/28	0.24 J	0.2 – 1	0.24	0.4				1,600	0.0002		100	0.002	
tert-Butyl methyl ether	µg/L	14/28	1.4 – 160	0.5 – 1	30	10	12	1×10^{-5}		6,300	0.03				
tert-Butylbenzene	µg/L	0/22	nd	0.2 – 1	nd	0.45									
Tetrachloroethene	µg/L	0/28	nd	0.2 – 1	nd	0.5	0.11		5×10^{-6}	220		0.002	5		0.1
Toluene	µg/L	2/28	0.60 – 4.8	0.2 – 1	2.7	0.6				2,300	0.002		1,000	0.005	

Table 4. Comparison of Groundwater Data with RSLs for the Hypothetical Future Resident Screening Assessment

Chemical	Unit	Detect Ratio	Detect or Range of Detects	RL or Range of RLs	Mean Detect	Mean Value	Cancer Tap Water RSL			Non-Cancer Tap Water RSL			Tap Water MCL or Non-Zero MCLG		
							RSL ^a	Excess Cancer Risk (Max Detect)	Excess Cancer Risk (Half Max RL) ^b	RSL ^a	HQ (Max Detect)	HQ (Half Max RL) ^b	MCL/ MCLG	EF (Max Detect)	EF (Half Max RL) ^b
trans-1,2-Dichloroethene	µg/L	0/22	nd	0.2 – 1	nd	0.45									
trans-1,3-Dichloropropene	µg/L	0/28	nd	0.2 – 1	nd	0.5									
Trichloroethene	µg/L	0/28	nd	0.2 – 1	nd	0.5	2		3×10^{-7}				5		0.1
Trichlorofluoromethane	µg/L	0/28	nd	0.2 – 1	nd	0.5				1,300		0.0004			
Vinyl acetate	µg/L	0/22	nd	1 – 5	nd	2.2				410		0.006			
Vinyl chloride	µg/L	1/28	0.22 J	0.2 – 1	0.22	0.4	0.016	1×10^{-5}		72	0.003		2	0.1	
o-Xylene	µg/L	2/28	4.0 – 6.0	0.2 – 1	5.0	0.8				1,200	0.005				
m,p-Xylene	µg/L	3/28	1.4 – 10	0.4 – 2	5	1				1,200	0.008				
Total xylenes	µg/L	3/28	1.4 – 20	0.4 – 2	10	2				200	0.1		10,000	0.002	
Petroleum															
TPH – gasoline range	mg/l	5/22	0.27 – 0.81	0.25	0.53	0.22									
TPH – diesel range	mg/l	1/22	0.26 J	0.25	0.26	0.14									
TPH – motor oil range	mg/l	0/22	nd	0.5	nd	0.25									
Total Risk^c								1×10^{-3}	1×10^{-2}		23	11		35	32

^a Cancer and non-cancer RSLs are from EPA (2009).

^b Exceedance factors based on half the maximum RL are shown only for chemicals never detected in groundwater.

^c The total exceedance factor is calculated using the higher of either dissolved or total water concentrations for chemicals where both sample types were analyzed.

BHC – benzene hexachloride

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

EDB – ethylene dibromide

EPA – US Environmental Protection Agency

EF – exceedance factor

HQ – hazard quotient

Bold indicates excess cancer risks greater than 1×10^{-6} or non-cancer HQs greater than 1.

J – estimated concentration

MCL – maximum contaminant level

MCLG – maximum contaminant level goal

na – not applicable

nd – not detected

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

RSL – regional screening level

SVOC – semivolatile organic compound

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

References

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ATTACHMENT 2 –METHODS FOR CALCULATING FISH TISSUE CONCENTRATIONS

Tissue data were not collected from the Harbor Oil Superfund Study Area for chemistry analysis. In order to estimate risks to people based on the consumption of fish in the human health risk assessment (HHRA), concentrations in fish tissues were estimated from concentrations in lake sediment.

Fish tissue concentrations were estimated from sediment using biota-sediment accumulation factors (BSAFs), which represent the steady-state relationship between concentrations in sediment and tissue. Other assumptions (i.e., tissue-specific moisture and lipid content, sediment organic carbon [OC] content) were also used to calculate fish tissue residue concentrations.

Equations 1 and 2 present how BSAFs are commonly derived as a ratio for inorganic (metals) and organic chemicals, respectively.

$$\text{BSAF} = \frac{C_{\text{tiss,dw}}}{C_{\text{sed,dw}}} \quad \text{Equation 1}$$

Where:

BSAF	ratio	chemical- and species-specific biota-sediment accumulation factor
$C_{\text{tiss,dw}}$	mg/kg dw	dry weight concentration in tissue
$C_{\text{sed,dw}}$	mg/kg dw	dry weight concentration in sediment

$$\text{BSAF} = \frac{C_{\text{tiss,ww}} / \text{Lipid}_{\text{tiss}}}{C_{\text{sed,dw}} / \text{OC}_{\text{sed}}} \quad \text{Equation 2}$$

Where:

BSAF	ratio	chemical - and species-specific biota-sediment accumulation factor
$C_{\text{tiss,ww}}$	mg/kg ww	wet weight concentration in tissue
$\text{Lipid}_{\text{tiss}}$	fraction	lipid content in tissue (expressed as a fraction)
$C_{\text{sed,dw}}$	mg/kg dw	dry weight concentration in sediment
OC_{sed}	fraction	organic carbon content in sediment (expressed as a fraction)

Fish tissue concentrations (C_{tiss}) used in the HHRA were derived on a sample-by-sample basis from Force Lake surface sediment concentrations (C_{sed}) by algebraically rearranging Equations 1 and 2 and using literature-based BSAFs and generic assumptions regarding moisture content and lipid content (Table 1). Moisture content was needed to convert BSAF-estimated dry weight tissue concentrations (for inorganic chemicals) into wet weight tissue concentrations. For organic compounds, Force Lake sediment concentrations were OC-normalized using the sample-specific total organic carbon (TOC) (Table 2), and tissue concentrations were converted from lipid-normalized concentrations to wet weight concentrations using an average fish lipid content.

Table 1. Assumptions Used to Estimate Tissue Concentrations

Parameter	Assumption	Source
Sediment TOC	see Table 2	Force Lake data
Moisture content – fish	72%	EPA (1993)
Lipid content – fish	3.7% ^a	EPA (2008)

^a Average reported lipid content for pumpkinseed, carp, and brown bullhead.

TOC – total organic carbon

Table 2. TOC Data Used to Estimate Organic Chemical Concentrations in Fish Tissue

Surface Sediment Sampling Location	TOC (%)
SE-01	6.71
SE-02	5.1
SE-03	6.54
SE-04	10.4
SE-05	6.02
SE-06	10.6
SE-07	13.1
SE-08	3.02
SE-09	8.44
SE-10	7.07
SE-11	1.34

TOC – total organic carbon

For inorganic chemicals, the following equation was used to estimate dry weight fish tissue concentrations on a sample-by-sample basis:

$$C_{\text{tiss,dw}} = C_{\text{sed,dw}} \times \text{BSAF} \quad \text{Equation 3}$$

Where:

$C_{\text{tiss,dw}}$ mg/kg dw sample-specific estimated dry weight tissue concentration
 $C_{\text{sed,dw}}$ mg/kg dw sample-specific dry weight Force Lake sediment concentration
 BSAF ratio chemical -specific fish biota-sediment accumulation factor

Inorganic chemical dry weight tissue concentrations were then converted into wet weight tissue concentrations using the following equation and fish percent moisture assumption:

$$C_{\text{tiss,ww}} = C_{\text{tiss,dw}} \times (1 - 0.72) \quad \text{Equation 4}$$

Where:

$C_{\text{tiss,ww}}$ mg/kg ww sample-specific estimated wet weight tissue concentration
 $C_{\text{tiss,dw}}$ mg/kg dw sample-specific estimated dry weight tissue concentration
 0.72 fraction fish moisture content (Table 1)

For organic compounds, the following equation and assumption were used to derive wet weight fish tissue concentrations:

$$C_{\text{tiss,ww}} = \left[\frac{C_{\text{sed,dw}}}{OC_{\text{sed}}} \times \text{BSAF} \right] \times 0.037 \quad \text{Equation 5}$$

Where:

$C_{\text{tiss,ww}}$	mg/kg ww	sample-specific estimated wet weight tissue concentration
$C_{\text{sed,dw}}$	mg/kg dw	sample-specific dry weight Force Lake sediment concentration
OC_{sed}	fraction	sample-specific TOC in sediment (expressed as a fraction)
BSAF	ratio	chemical -specific fish biota-sediment accumulation factor
0.037	fraction	fish lipid content (Table 1)

A search for fish literature-based BSAFs was conducted for all chemicals analyzed in lake sediment, with particular emphasis on chemicals detected in lake sediment. BSAFs were selected from a variety of sources; their availability varied depending on the chemical class and modeled species. BSAFs were selected based on the following hierarchy:

- Fish and invertebrate BSAFs for organic chemicals were based on EPA's BSAF database (EPA 2008) when available.
- Fish BSAFs were derived as the mean BSAF reported in the collection of BSAFs compiled by PTI (1995a, b).
- A surrogate BSAF was used for some related chemicals (e.g., technical chlordane was used as a surrogate for total chlordane).
- A default value of 1 was used for chemicals with no published value from the above sources. The use of this default value assumed that sediment and tissue concentrations were equal, which is a conservative assumption for chemicals that are regulated by fish (e.g., metals) or do not accumulate (e.g., VOCs) and would therefore have BSAFs lower than 1. The default BSAF assumption of 1 could underestimate risks for bioaccumulative chemicals; however, literature-based BSAFs are available for the key known bioaccumulative chemicals such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDTs).

The US Army Corps of Engineers (USACE) BSAF database (2008) was used as a secondary source for obtaining BSAFs; however, units for BSAFs in this database were not clearly presented (i.e., whether BSAFs for organics were expressed as lipid- and OC-normalized tissue and sediment concentration ratios or as unadjusted tissue and sediment concentration ratios); thus, these BSAFs were not used.

Based on above sources, Table 3 presents the fish BSAFs used in the HHRA and their source.

Table 3. Fish BSAFs Used in the HHRA

Chemical	BSAF^a	Source and Details on Selected Value
Metals (dw/dw)		
Antimony	1	No fish BSAF was available from the literature; default value was used.
Arsenic	0.12	Only fish BSAF was presented in PTI (1995b).
Barium	1	No fish BSAF was available from the literature; default value was used.
Cadmium	0.785	Based on the mean BSAF reported by PTI (1995b); value was based on nine BSAFs ranging from 0.043 to 2.0 compiled from one location.
Chromium	0.043	Only fish BSAF was presented in PTI (1995b).
Cobalt	1	No fish BSAF was available from the literature; default value was used.
Copper	1	No fish BSAF was available from the literature; default value was used.
Lead	0.180	Based on the mean BSAF reported by PTI (1995b); value was based on nine BSAFs ranging from 0.028 to 0.43 compiled from one location.
Mercury	0.38	Only fish BSAF was presented in PTI (1995b).
Nickel	1	No fish BSAF was available from the literature; default value was used.
Selenium	1	No fish BSAF was available from the literature; default value was used.
Vanadium	1	No fish BSAF was available from the literature; default value was used.
Zinc	1.83	Based on the mean BSAF reported by PTI (1995b); value was based on 10 BSAFs ranging from 0.13 to 5.0 compiled from two locations.
PAHs (lipid/OC)		
2-Methylnaphthalene	0.147	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 14 BSAFs ranging from 0.0109 to 0.972.
Acenaphthene	0.0313	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 11 BSAFs ranging from 0.00484 to 0.0602.
Acenaphthylene	0.0138	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 11 BSAFs ranging from 0.00032 to 0.0287.
Anthracene	0.0078	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 15 BSAFs ranging from 0.00020 to 0.0148.
Benzo(a)anthracene	0.0135	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 8 BSAFs ranging from 0.00030 to 0.0941.
Benzo(a)pyrene	0.0021	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 4 BSAFs ranging from 0.00023 to 0.0040.
Benzo(b)fluoranthene	0.0025	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 5 BSAFs ranging from 0.00022 to 0.0043.

Table 3. Fish BSAFs Used in the HHRA

Chemical	BSAF^a	Source and Details on Selected Value
Benzo(g,h,i)perylene	0.0250	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 3 BSAFs ranging from 0.00118 to 0.0699.
Benzo(k)fluoranthene	0.0023	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 5 BSAFs ranging from 0.00021 to 0.0041.
Chrysene	0.0100	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 8 BSAFs ranging from 0.00032 to 0.0636.
Dibenzo(a,h)anthracene	0.0022	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 5 BSAFs ranging from 0.00031 to 0.0043.
Dibenzofuran	0.0259	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 12 BSAFs ranging from 0.00211 to 0.0496.
Fluoranthene	0.0056	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 15 BSAFs ranging from 0.00008 to 0.0383.
Fluorene	0.0626	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 16 BSAFs ranging from 0.00058 to 0.5256.
Indeno(1,2,3-cd)pyrene	0.0144	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 6 BSAFs ranging from 0.00021 to 0.0756.
Naphthalene	0.135	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 11 BSAFs ranging from 0.0123 to 0.813.
Phenanthrene	0.0237	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 17 BSAFs ranging from 0.00021 to 0.161.
Pyrene	0.0158	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 8 BSAFs ranging from 0.00025 to 0.0638.
cPAH TEQ	0.0021	Based on the mean BSAF for benzo(a)pyrene reported in EPA's BSAF database (EPA 2008) for all fish species. ^b
Other SVOCs (lipid/OC)		
1,2,4-Trichlorobenzene	0.132	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 2 BSAFs ranging from 0.0770 to 0.186.
1,2-Dichlorobenzene	0.112	Based on the only BSAF reported in EPA's BSAF database (EPA 2008).
1,3-Dichlorobenzene	0.020	Based on the only BSAF reported in EPA's BSAF database (EPA 2008).
1,4-Dichlorobenzene	0.014	Based on the only BSAF reported in EPA's BSAF database (EPA 2008).
Hexachlorobenzene	0.015	Based on the geometric mean BSAF reported by PTI (1995a).
Hexachlorobutadiene	0.015	Based on the geometric mean BSAF reported by PTI (1995a).

Table 3. Fish BSAFs Used in the HHRA

Chemical	BSAF ^a	Source and Details on Selected Value
PCBs (lipid/OC)		
Total PCBs	6.45	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 285 BSAFs ranging from 0.00375 to 258.
Pesticides (lipid/OC)		
Aldrin	1	No fish BSAF was available from the literature; default value was used.
alpha-BHC	1	No fish BSAF was available from the literature; default value was used.
alpha-Chlordane	1.46	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 27 BSAFs ranging from 0.146 to 6.13.
alpha-Endosulfan	1	No fish BSAF was available from the literature; default value was used.
beta-BHC	1	No fish BSAF was available from the literature; default value was used.
beta-Endosulfan	1	No fish BSAF was available from the literature; default value was used.
delta-BHC	1	No fish BSAF was available from the literature; default value was used.
Dieldrin	2.23	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 21 BSAFs ranging from 0.0931 to 17.9
Endosulfan sulfate	1	No fish BSAF was available from the literature; default value was used
Endrin	1	No fish BSAF was available from the literature; default value was used
Endrin aldehyde	1	No fish BSAF was available from the literature; default value was used
Endrin ketone	1	No fish BSAF was available from the literature; default value was used
gamma-BHC	1	No fish BSAF was available from the literature; default value was used
gamma-Chlordane	1.14	Based on the mean BSAF reported in EPA's BSAF database (EPA 2008) for all fish species; value was based on 17 BSAFs ranging from 0.0981 to 3.43.
Heptachlor	0.13	Based on the geometric mean BSAF reported by PTI (1995a).
Heptachlor epoxide	29	Based on the geometric mean BSAF reported by PTI (1995a).
Methoxychlor	1	No fish BSAF was available from the literature; default value was used.
Total aldrin/dieldrin	1	No fish BSAF was available from the literature; default value was used.
Total chlordane	26	Based on the geometric mean BSAF reported by PTI (1995a); surrogate = technical chlordane.
Total DDTs	3.0	Based on the weighted average of BSAFs for the three DDT components detected in Force Lake: 16% 2,4'-DDD (geometric mean BSAF of 0.045 from PTI (1995a)), 29% 4,4'-DDD (mean BSAF of 0.83 from EPA (2008)), and 55% 4,4'-DDE (mean BSAF of 5.00 from EPA (2008)).
Toxaphene	1	No fish BSAF was available from the literature; default value was used.

Table 3. Fish BSAFs Used in the HHRA

Chemical	BSAF ^a	Source and Details on Selected Value
VOCs (lipid/OC)		
All VOCs analyzed in sediment	1	No fish BSAF was available from the literature for any VOCs; default value was used for all VOCs.

^a All metal BSAFs are expressed as the ratio of tissue concentration (in dry weight) over sediment concentration (in dry weight); all BSAFs for organic chemicals are expressed as the ratio of tissue concentration (as a lipid-normalized concentration) over sediment concentration (as an OC-normalized concentration).

^b The cPAH TEQ sum was calculated based on PEFs, which relate the seven cPAHs in the Harbor Oil dataset to the most toxic of these chemicals (benzo[a]pyrene), as described in Section 2.2.4 of the HHRA and Cal EPA (1994). Thus, the benzo(a)pyrene BSAF was used for cPAH TEQ.

BSAF – biota sediment accumulation factor

Cal EPA – California Environmental Protection Agency

cPAH – carcinogenic polycyclic aromatic hydrocarbon

EPA – US Environmental Protection Agency

OC – organic carbon

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PEF – potency equivalency factor

SVOC – semivolatile organic compound

TEQ – toxic equivalent

VOC – volatile organic compound

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ATTACHMENT 3 – SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

This attachment to the Harbor Oil baseline HHRA presents summary statistics for chemicals analyzed at the Harbor Oil Facility and documents the process for the selection of contaminants of potential concern (COPCs) using the table format suggested in RAGS Part D (EPA 1998). The process used to select COPCs is summarized in Section 3.2 of the main document and is based on the comparison of maximum values to the appropriate literature regional screening levels (RSLs).

This attachment provides a separate table for each scenario-exposure media combination. Note that conventional parameters (e.g., salinity, pH, clay, coarse sand, total organic carbon, total solids) are not included in these tables.

- Table 1: Occurrence and selection of COPCs for Facility Soil in the Industrial (Construction/Trenching) Worker RME (reasonable maximum exposure) Scenario
- Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario
- Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario
- Table 4: Occurrence and selection of COPCs for Groundwater in the Industrial/Commercial Worker Vapor Intrusion Scenario
- Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario
- Table 6: Occurrence and selection of COPCs for Lake Sediment in the Force Lake Recreational User RME Scenario
- Table 7: Occurrence and selection of COPCs for Lake Surface Water in the Force Lake Recreational User RME Scenario
- Table 8: Occurrence and selection of COPCs for Calculated Fish Tissue in the Force Lake Fish Consumer RME Scenario

Table 1: Occurrence and selection of COPCs for Facility Soil in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value Used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Metals											
Aluminum	7429-90-5	18/18	5,280	12,100	mg/kg dw	na	12,100	na	990,000	no	bsl
Antimony	7440-36-0	4/112	0.7 J	8.4 J	mg/kg dw	0.2 UJ – 4.5 U	8.4 J	4	41	no	bsl
Arsenic	7440-38-2	112/112	0.7	53.1	mg/kg dw	na	53.1	7	1.6	yes	asl
Barium	7440-39-3	112/112	36.5	1,170 J	mg/kg dw	na	1,170 J	na	6,200	no	bsl
Beryllium	7440-41-7	18/18	0.29	0.7	mg/kg dw	na	0.7	na	61	no	bsl
Cadmium	7440-43-9	67/112	0.2	4	mg/kg dw	0.2 UJ – 0.3 U	4	1	80	no	bsl
Calcium	7440-70-2	18/18	3,040	18,500	mg/kg dw	na	18,500	na	na	no	ntx
Chromium	7440-47-3	112/112	4.0	111	mg/kg dw	na	111	42	180	no	bsl
Cobalt	7440-48-4	112/112	2.7 J	35 J	mg/kg dw	na	35 J	na	30	yes	asl
Copper	7440-50-8	112/112	6.1 J	1,370	mg/kg dw	na	1,370	36	1,100	yes	asl
Iron	7439-89-6	18/18	1,400	56,500	mg/kg dw	na	56,500	na	720,000	no	bsl
Lead	7439-92-1	112/112	3	337	mg/kg dw	na	337	17	30	yes	asl
Magnesium	7439-95-4	18/18	2,880	5,370	mg/kg dw	na	5,370	na	na	no	ntx
Manganese	7439-96-5	18/18	158	1,090	mg/kg dw	na	1,090	na	1,400	no	bsl
Mercury	7439-97-6	56/112	0.03	6.69	mg/kg dw	0.03 U – 0.07 U	6.69	0.07	9.3	no	bsl
Nickel	7440-02-0	112/112	4	50 J	mg/kg dw	na	50 J	38	620	no	bsl
Potassium	7440-09-7	18/18	576	2,030	mg/kg dw	na	2,030	na	72	no	his ^c
Selenium	7782-49-2	8/112	0.1	1.1	mg/kg dw	0.1 U – 3 U	3 U	2	510	no	bsl
Silver	7440-22-4	17/18	0.42	3.16	mg/kg dw	0.4 U – 0.4 U	3.16	na	150	no	bsl
Sodium	7440-23-5	18/18	286	850	mg/kg dw	na	850	na	na	no	ntx
Thallium	7440-28-0	0/18	nd	nd	mg/kg dw	0.3 U – 0.75 U	0.75 U	na	6.6	no	bsl
Vanadium	7440-62-2	112/112	15.5 J	165	mg/kg dw	na	165	na	520	no	bsl
Zinc	7440-66-6	112/112	22 J	785 J	mg/kg dw	na	785 J	86	310,000	no	bsl
PAHs											
2-Chloronaphthalene	91-58-7	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	82,000,000	no	bsl
2-Methylnaphthalene	91-57-6	95/115	5.4	29,000	µg/kg dw	4.8 U – 172 U	29,000	na	4,100,000	no	bsl
Acenaphthene	83-32-9	63/115	5.0	28,000	µg/kg dw	4.6 U – 883 U	28,000	na	1,600,000	no	bsl
Acenaphthylene	208-96-8	20/115	5.3	836 J	µg/kg dw	4.5 U – 735 U	836 J	na	3,300,000	no	bsl
Anthracene	120-12-7	96/115	4.8	110,000	µg/kg dw	4.8 U – 735 U	110,000	na	9,000,000	no	bsl
Benzo(a)anthracene	56-55-3	95/115	5.0	8,800	µg/kg dw	4.8 U – 883 U	8,800	na	2100	yes	teq
Benzo(a)pyrene	50-32-8	98/115	5.0	3,800	µg/kg dw	4.8 U – 350 U	3,800	na	210	yes	teq
Benzo(b)fluoranthene	205-99-2	100/115	5.4	3,000	µg/kg dw	4.8 U – 1,470 U	3,000	na	2100	yes	teq
Benzo(g,h,i)perylene	191-24-2	96/115	5.0	3,390 J	µg/kg dw	4.8 U – 874 U	3,390 J	na	na	no	ntx
Benzo(k)fluoranthene	207-08-9	94/115	5.4	3,500	µg/kg dw	4.8 U – 883 U	3,500	na	21,000	no	teq
Total benzofluoranthenes	56832-73-6	101/115	6.4	6,400	µg/kg dw	4.8 U – 1,470 U	6,400	na	na	no	ntx

Table 1: Occurrence and selection of COPCs for Facility Soil in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value Used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Chrysene	218-01-9	105/115	5.9	13,000	µg/kg dw	4.8 U – 735 U	13,000	na	210,000	no	teq
Dibenzo(a,h)anthracene	53-70-3	39/115	5.0 JN	420	µg/kg dw	4.6 U – 8,830 U	8,830 U	na	210	yes	teq
Dibenzofuran	132-64-9	75/115	5.1	18,000	µg/kg dw	4.5 U – 735 U	18,000	na	na	no	ntx
Fluoranthene	206-44-0	106/115	6.0	35,000	µg/kg dw	4.8 U – 172 U	35,000	na	890,000	no	bsl
Fluorene	86-73-7	70/115	6.2	40,000	µg/kg dw	4.6 U – 735 U	40,000	na	1,200,000	no	bsl
Indeno(1,2,3-cd)pyrene	193-39-5	87/115	5.9	3,830 J	µg/kg dw	4.7 U – 1,750 U	3,830 J	na	2,100	yes	teq
Naphthalene	91-20-3	85/115	4.8	19,000	µg/kg dw	4.8 U – 242 U	19,000	na	410	yes	asl
Phenanthrene	85-01-8	107/115	5.4 J	77,000	µg/kg dw	5.0 U – 172 U	77,000	na	na	no	ntx
Pyrene	129-00-0	109/115	6.5	31,000	µg/kg dw	4.8 U – 172 U	31,000	na	670,000	no	bsl
Total HPAHs	na	110/115	12.5	99,000	µg/kg dw	4.8 U – 1,720 U	99,000	na	na	no	ntx
Total LPAHs	na	107/115	5.4 J	260,000	µg/kg dw	5.0 U – 172 U	260,000	na	na	no	ntx
cPAH TEQ	na	106/115	5.00	5,200	µg/kg dw	4.30 U – 637 U	5,200	na	210	yes	asl
Total PAHs	na	113/115	7.8	360,000	µg/kg dw	1,200 U – 1,720 U	360,000	na	na	no	ntx
Phthalates											
Bis(2-ethylhexyl)phthalate	117-81-7	35/46	11 J	5,730	µg/kg dw	20 U – 175 U	5,730	na	120,000	no	bsl
Butyl benzyl phthalate	85-68-7	8/46	86	3,140 J	µg/kg dw	20 U – 3,680 U	3,680 U	na	910,000	no	bsl
Diethyl phthalate	84-66-2	1/46	184 J	184 J	µg/kg dw	20 U – 883 U	883 U	na	490,000,000	no	bsl
Dimethyl phthalate	131-11-3	0/46	nd	nd	µg/kg dw	20 U – 1,770 U	1,770 U	na	na	no	ntx
Di-n-butyl phthalate	84-74-2	3/46	56	194	µg/kg dw	20 U – 883 U	883 U	na	6,200,000	no	bsl
Di-n-octyl phthalate	117-84-0	0/46	nd	nd	µg/kg dw	20 U – 4,420 U	4,420 U	na	na	no	ntx
Other SVOCs											
1,2,4-Trichlorobenzene	120-82-1	2/113	7.2 J	24 J	µg/kg dw	2.2 U – 4,000 U	4,000 U	na	400,000	no	bsl
1,2-Dichlorobenzene	95-50-1	19/112	1.3	980	µg/kg dw	0.9 U – 440 U	980	na	3,800	no	bsl
1,3-Dichlorobenzene	541-73-1	7/111	1.3	120 J	µg/kg dw	0.9 U – 810 U	810 U	na	1,100	no	bsl
1,4-Dichlorobenzene	106-46-7	20/112	1.6	490 J	µg/kg dw	0.9 U – 810 U	810 U	na	540	no	ife
2,4,5-Trichlorophenol	95-95-4	0/46	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	6,200,000	no	bsl
2,4,6-Trichlorophenol	88-06-2	0/46	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	13,000	no	bsl
2,4-Dichlorophenol	120-83-2	0/46	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	180,000	no	bsl
2,4-Dimethylphenol	105-67-9	4/46	69.4 J	480	µg/kg dw	20 U – 883 U	883 U	na	1,200,000	no	bsl
2,4-Dinitrophenol	51-28-5	0/44	nd	nd	µg/kg dw	200 U – 17,700 U	17,700 U	na	120,000	no	bsl
2,4-Dinitrotoluene	121-14-2	0/46	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	5,500	no	bsl
2,6-Dinitrotoluene	606-20-2	0/46	nd	nd	µg/kg dw	98 U – 8,830 U	8,830 U	na	1,700	yes	asl
2-Chlorophenol	95-57-8	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	510,000	no	bsl
2-Methylphenol	95-48-7	3/46	78 J	518	µg/kg dw	20 U – 883 U	883 U	na	3,100,000	no	bsl
2-Nitroaniline	88-74-4	0/46	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	180,000	no	bsl
2-Nitrophenol	88-75-5	0/46	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	na	no	ntx

Table 1: Occurrence and selection of COPCs for Facility Soil in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value Used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
3,3'-Dichlorobenzidine	91-94-1	0/44	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	200	yes	asl
3-Nitroaniline	99-09-2	0/46	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	na	no	ntx
4,6-Dinitro-o-cresol	534-52-1	0/46	nd	nd	µg/kg dw	200 U – 8,830 U	8,830 U	na	6,200	no	ife
4-Bromophenyl phenyl ether	101-55-3	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	na	no	ntx
4-Chloro-3-methylphenol	59-50-7	0/46	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	na	no	ntx
4-Chloroaniline	106-47-8	0/46	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	8,600	no	bsl
4-Chlorophenyl phenyl ether	7005-72-3	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	na	no	ntx
4-Methylphenol	106-44-5	11/46	17 J	1,240	µg/kg dw	20 U – 883 U	1,240	na	310,000	no	bsl
4-Nitroaniline	100-01-6	0/46	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	86,000	no	bsl
4-Nitrophenol	100-02-7	0/46	nd	nd	µg/kg dw	98 U – 8,830 U	8,830 U	na	na	no	ntx
Acetophenone	98-86-2	3/18	68.2 J	630 J	µg/kg dw	119 U – 1,730 U	1,730 U	na	100,000,000	no	bsl
Aniline	62-53-3	0/27	nd	nd	µg/kg dw	20 U – 440 U	440 U	na	300,000	no	bsl
Atrazine	1912-24-9	0/18	nd	nd	µg/kg dw	596 U – 4,420 U	4,420 U	na	7,500	no	bsl
Benzaldehyde	100-52-7	3/17	37.2 J	1,080 J	µg/kg dw	119 U – 288 U	1,080 J	na	100,000,000	no	bsl
Benzoic acid	65-85-0	8/28	120 J	820	µg/kg dw	200 U – 4,400 U	4,400 U	na	2.5 x 10 ⁹	no	bsl
Benzyl alcohol	100-51-6	3/28	17 J	170	µg/kg dw	20 U – 440 U	440 U	na	310,000,000	no	bsl
Biphenyl	92-52-4	7/18	44.7 J	1,000	µg/kg dw	119 U – 735 U	1,000	na	51,000,000	no	bsl
bis(2-chloroethoxy)methane	111-91-1	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	180,000	no	bsl
bis(2-chloroethyl)ether	111-44-4	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	900	no	bsl
bis(2-chloroisopropyl)ether	108-60-1	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	17,000	no	bsl
Caprolactam	105-60-2	0/18	nd	nd	µg/kg dw	596 U – 4,420 U	4,420 U	na	310,000,000	no	bsl
Carbazole	86-74-8	9/46	12 J	940	µg/kg dw	20 U – 883 U	940	na	na	no	ntx
Hexachlorobenzene	118-74-1	4/115	3.2	230	µg/kg dw	0.96 U – 4,800 U	4,800 U	na	1,100	no	ife
Hexachlorobutadiene	87-68-3	0/116	nd	nd	µg/kg dw	0.96 U – 4,000 U	4,000 U	na	22,000	no	bsl
Hexachlorocyclopentadiene	77-47-4	0/45	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	370,000	no	bsl
Hexachloroethane	67-72-1	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	16,000	no	bsl
Isophorone	78-59-1	0/46	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	1,800,000	no	bsl
Nitrobenzene	98-95-3	0/46	nd	nd	µg/kg dw	20 U – 2,000 U	2,000 U	na	22,000	no	bsl
n-Nitroso-di-n-propylamine	621-64-7	0/46	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	250	yes	asl
n-Nitrosodiphenylamine	86-30-6	0/46	nd	nd	µg/kg dw	20 U – 2,500 U	2,500 U	na	350,000	no	bsl
Pentachlorophenol	87-86-5	0/46	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	3,500	no	ife
Phenol	108-95-2	8/46	53	825	µg/kg dw	20 U – 440 U	825	na	180,000,000	no	bsl
PCBs											
Aroclor-1016	12674-11-2	0/114	nd	nd	µg/kg dw	15 U – 650 U	650 U	na	21,000	no	sum
Aroclor-1221	11104-28-2	0/114	nd	nd	µg/kg dw	30 U – 650 U	650 U	na	620	no	sum
Aroclor-1232	11141-16-5	0/114	nd	nd	µg/kg dw	15 U – 650 U	650 U	na	620	no	sum

Table 1: Occurrence and selection of COPCs for Facility Soil in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value Used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Aroclor-1242	53469-21-9	2/114	140	1,300	µg/kg dw	15 U – 360 U	1,300	na	740	no	sum
Aroclor-1248	12672-29-6	29/114	46	14,000	µg/kg dw	15 U – 650 U	14,000	na	740	no	sum
Aroclor-1254	11097-69-1	20/114	65	8,200	µg/kg dw	15 U – 1,700 U	8,200	na	740	no	sum
Aroclor-1260	11096-82-5	69/114	4.9 J	9,900	µg/kg dw	17 U – 650 U	9,900	na	740	no	sum
Total PCBs	1336-36-3	74/114	4.9 J	32,000	µg/kg dw	32 U – 200 U	32,000	na	740	yes	asl
Pesticides											
2,4'-DDD	53-19-0	68/97	2.8	12,000	µg/kg dw	1.9 U – 540 U	12,000	na	na	no	sum
2,4'-DDE	3424-82-6	1/97	7.0	7.0	µg/kg dw	1.9 U – 9,600 U	9,600 U	na	na	no	sum
2,4'-DDT	789-02-6	5/97	3.0 J	920	µg/kg dw	1.9 U – 9,600 U	9,600 U	na	na	no	sum
4,4'-DDD	72-54-8	102/115	2.4 J	64,000	µg/kg dw	0.6 U – 130 U	64,000	na	7,200	no	sum
4,4'-DDE	72-55-9	46/115	1.6	5,200 J	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	5,100	no	sum
4,4'-DDT	50-29-3	46/115	0.95	8,400	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,000	no	sum
Total DDTs	na	104/115	2.4 J	78,000 J	µg/kg dw	0.6 U – 130 U	78,000 J	na	7,000	yes	asl
Aldrin	309-00-2	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	100	no	ife
Dieldrin	60-57-1	0/115	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	110	yes	asl
Total aldrin/dieldrin	na	0/115	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	na	no	ntx
alpha-BHC	319-84-6	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	35	yes	asl
beta-BHC	319-85-7	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	960	no	ife
gamma-BHC	58-89-9	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	100	no	ife
delta-BHC	319-86-8	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
alpha-Chlordane	5103-71-9	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
gamma-Chlordane	5103-74-2	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
Total chlordane	57-74-9	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
alpha-Endosulfan	959-98-8	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	140,000	no	bsl
beta-Endosulfan	33213-65-9	0/115	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	140,000	no	bsl
Endosulfan sulfate	1031-07-8	0/115	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	140,000	no	bsl
Endrin	72-20-8	1/115	2.6	2.6	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,100	no	ife
Endrin aldehyde	7421-93-4	0/115	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,100	no	ife
Endrin ketone	53494-70-5	0/115	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,100	no	ife
Heptachlor	76-44-8	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	380	no	ife
Heptachlor epoxide	1024-57-3	0/115	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	190	no	ife
Methoxychlor	72-43-5	0/115	nd	nd	µg/kg dw	0.6 U – 48,000 U	48,000 U	na	310,000	no	bsl
Toxaphene	8001-35-2	0/115	nd	nd	µg/kg dw	96 UJ – 480,000 U	480,000 U	na	1,600	yes	asl
VOCs											
1,1,1,2-Tetrachloroethane	630-20-6	0/95	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	9,800	no	bsl
1,1,1-Trichloroethane	71-55-6	1/113	170	170	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	15,000	no	bsl

Table 1: Occurrence and selection of COPCs for Facility Soil in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value Used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
1,1,2,2-Tetrachloroethane	79-34-5	0/111	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	2,900	no	bsl
1,1,2-Trichloroethane	79-00-5	2/113	1.5 J	41	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	190	no	ife
1,1,2-Trichlorotrifluoroethane	76-13-1	0/113	nd	nd	µg/kg dw	1.8 U – 2,200 U	2,200 U	na	180,000,000	no	bsl
1,1-Dichloroethane	75-34-3	4/113	1.1	680	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	190	yes	asl
1,1-Dichloroethene	75-35-4	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	4,300	no	bsl
1,1-Dichloropropene	563-58-6	0/95	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
1,2,3-Trichlorobenzene	87-61-6	0/93	nd	nd	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	na	no	ntx
1,2,3-Trichloropropane	96-18-4	0/93	nd	nd	µg/kg dw	1.8 U – 2,200 U	2,200 U	na	410	no	ife
1,2,4-Trimethylbenzene	95-63-6	49/95	1.3 J	40,000	µg/kg dw	0.9 U – 7.1 UJ	40,000	na	5,500	yes	asl
1,2-Dibromo-3-chloropropane	96-12-8	0/113	nd	nd	µg/kg dw	3 UJ – 5,600 U	5,600 U	na	73	yes	asl
1,2-Dibromoethane (EDB)	106-93-4	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	0.44	yes	asl
1,2-Dichloroethane	107-06-2	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	7.4	yes	asl
1,2-Dichloroethene (total)	540-59-0	0/18	nd	nd	µg/kg dw	2.2 U – 4.7 U	4.7 U	na	50,000	no	bsl
1,2-Dichloropropane	78-87-5	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	4,700	no	bsl
1,3,5-Trimethylbenzene	108-67-8	34/95	1.3	12,000	µg/kg dw	0.9 U – 120 U	12,000	na	1,200	yes	asl
1,3-Dichloropropane	142-28-9	0/95	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	20,000,000	no	bsl
2,2-Dichloropropane	594-20-7	0/95	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
2-Chlorotoluene	95-49-8	0/93	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	20,000,000	no	bsl
2-Hexanone	591-78-6	0/113	nd	nd	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	na	no	ntx
4-Chlorotoluene	106-43-4	0/93	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	72,000,000	no	bsl
Acetone	67-64-1	83/113	11	1,800	µg/kg dw	5.6 U – 5,600 U	5,600 U	na	610,000,000	no	bsl
Benzene	71-43-2	52/113	1.1	6,400	µg/kg dw	0.9 U – 810 U	6,400	na	52	yes	asl
Bromobenzene	108-86-1	0/93	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	41,000	no	bsl
Bromochloromethane	74-97-5	0/95	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
Bromodichloromethane	75-27-4	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	23	yes	asl
Bromoform	75-25-2	0/111	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	1,600	no	bsl
Bromomethane	74-83-9	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	39	yes	asl
Carbon disulfide	75-15-0	38/113	1.3	460	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	3,000,000	no	bsl
Carbon tetrachloride	56-23-5	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	70	yes	asl
Chlorobenzene	108-90-7	24/113	1.2 JN	2,900 J	µg/kg dw	0.9 U – 1,100 U	2,900 J	na	2,600	yes	asl
Chloroethane	75-00-3	1/113	2.9	2.9	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	370	no	ife
Chloroform	67-66-3	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	18	yes	asl
Chloromethane	74-87-3	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	150	no	ife
cis-1,2-Dichloroethene	156-59-2	10/113	1.2	130,000	µg/kg dw	0.9 U – 1,100 U	130,000	na	400	yes	asl
cis-1,3-Dichloropropene	10061-01-5	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	8400	no	bsl
Cyclohexane	110-82-7	3/18	1.3 J	31.6 J	µg/kg dw	2.2 U – 4.3 UJ	31.6 J	na	30,000,000	no	bsl

Table 1: Occurrence and selection of COPCs for Facility Soil in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value Used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
p-Cymene	99-87-6	27/95	1.3	11,000 J	µg/kg dw	0.9 U – 98 U	11,000 J	na	na	no	ntx
Dibromochloromethane	124-48-1	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	3,400	no	bsl
Dibromomethane	74-95-3	0/95	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	10,000,000	no	bsl
Dichlorodifluoromethane	75-71-8	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	78,000	no	bsl
Dichloromethane	75-09-2	27/113	2.0	370	µg/kg dw	1.9 U – 2,200 U	2,200 U	na	230	yes	asl
Ethylbenzene	100-41-4	35/113	1.4	26,000	µg/kg dw	0.9 U – 120 U	26,000	na	860	yes	asl
Isopropylbenzene	98-82-8	37/111	1.3	2,300	µg/kg dw	0.9 U – 120 U	2,300	na	2,400,000	no	bsl
Methyl acetate	79-20-9	0/18	nd	nd	µg/kg dw	11.1 UJ – 23.3 UJ	23.3 UJ	na	1.0 x 10 ⁹	no	bsl
Methyl ethyl ketone	78-93-3	53/113	7.0	240	µg/kg dw	4.8 U – 5,600 U	5,600 U	na	na	no	ntx
Methyl isobutyl ketone	108-10-1	6/113	5.2 J	100	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	na	no	ntx
Methylcyclohexane	108-87-2	6/18	3.7	185 J	µg/kg dw	2.2 U – 4.3 UJ	185 J	na	na	no	ntx
n-Butylbenzene	104-51-8	33/95	1.3	12,000	µg/kg dw	0.9 U – 83 U	12,000	na	na	no	ntx
n-Propylbenzene	103-65-1	37/94	1.3	6,700	µg/kg dw	0.9 U – 120 U	6,700	na	230,000	no	bsl
sec-Butylbenzene	135-98-8	22/93	1.2	2,000	µg/kg dw	0.9 U – 1,100 U	2,000	na	16,000	no	bsl
Styrene	100-42-5	1/113	1.9	1.9	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	5,000,000	no	bsl
tert-Butyl methyl ether	1634-04-4	15/113	2.2	69	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	500	no	ife
tert-Butylbenzene	98-06-6	1/93	2.0	2.0	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
Tetrachloroethene	127-18-4	6/113	1.9	10.8 J	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	2,700	no	bsl
Toluene	108-88-3	54/113	1.2	49,000	µg/kg dw	0.9 U – 810 U	49,000	na	2,400,000	no	bsl
trans-1,2-Dichloroethene	156-60-5	1/95	5,500	5,500	µg/kg dw	0.9 U – 1,100 U	5,500	na	1,000	yes	asl
trans-1,3-Dichloropropene	10061-02-6	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	8,400	no	bsl
Trichloroethene	79-01-6	9/113	1.5	2,400	µg/kg dw	0.9 U – 1,100 U	2,400	na	9.9	yes	asl
Trichlorofluoromethane	75-69-4	0/113	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	29,000	no	bsl
Vinyl acetate	108-05-4	0/93	nd	nd	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	4,200,000	no	bsl
Vinyl chloride	75-01-4	2/113	13	1,200	µg/kg dw	0.9 U – 1,100 U	1,200	na	10	yes	asl
o-Xylene	95-47-6	43/113	1.2	33,000	µg/kg dw	0.9 U – 380 U	33,000	na	10,000	no	sum
m,p-Xylene	108383/ 106423	49/113	1.1 J	120,000 J	µg/kg dw	0.9 U – 380 U	120,000 J	na	10,000	no	sum
Total xylenes	1330-20-7	53/113	1.1 J	150,000 J	µg/kg dw	0.9 U – 380 U	150,000 J	na	10,000	yes	asl
Petroleum^d											
TPH - Gasoline range	na	49/97	5.3	3,800	mg/kg dw	5.6 U – 57 U	3,800	na	110	yes	asl
TPH - Diesel range	na	104/110	6.3	13,000	mg/kg dw	6.3 U – 29 U	13,000	na	23,000	no	bsl
TPH - Motor oil range	na	108/110	14	12,000	mg/kg dw	13 U – 14 U	12,000	na	40,000	no	bsl

^a Background values are from DEQ (2002).

- ^b The worker soil RSL is the lowest of EPA industrial screening levels (2009d) and DEQ human health occupational, construction worker, or excavation worker RBCs for the following four exposure routes: soil ingestion, dermal absorption, and inhalation; volatilization to outdoor air; vapor intrusion into buildings; and leaching to groundwater (2007). For TPHs, the screening level is the lowest occupational DEQ RBC (2003).
- ^c Potassium was analyzed only in historical data, but not in samples collected in the RI/FS sampling effort because potassium is an essential nutrient and is not expected to be toxic to humans based on the daily reference intake for potassium of 4.7 g/day (Institute of Medicine 2004).
- ^d Aromatic and aliphatic TPHs were assumed to be equal to 15% and 85% of the TPH total for each of the three fractions (gasoline, diesel, and motor oil) based on ATSDR (1999). For the purposes of this HHRA, only aliphatic TPHs were carried forward as COPCs when above screening levels because the components of the aromatic TPHs (e.g., various PAHs and VOCs) were already assessed and thus the assessment of aromatic TPHs as an additional chemical group would double count risks.

asl – above screening level (selected as COPC)	his – chemical analyzed only in historical data	PAH – polycyclic aromatic hydrocarbon
BHC – benzene hexachloride	HPAH – high-molecular-weight polycyclic aromatic hydrocarbon	PCB – polychlorinated biphenyl
bsl – below screening level		RBC – risk-based concentration
COPC – contaminant of potential concern		RSL – regional screening level
CAS – Chemical Abstracts Service	ife – infrequent exceedance of RSL by RLs (not selected as COPC)	sum – chemical included in sum and is not evaluated separately
cPAH – carcinogenic PAH	J – estimated concentration	SVOC – semivolatile organic compound
DDD – dichlorodiphenyldichloroethane	LPAH – low-molecular-weight polycyclic aromatic hydrocarbon	teq – chemical included in TEQ calculation and is not evaluated separately
DDE – dichlorodiphenyldichloroethylene	na – not available	TEQ – toxic equivalent
DDT – dichlorodiphenyltrichloroethane	N – tentative identification	TPH – total petroleum hydrocarbons
dw – dry weight	ND – not detected	U – not detected at given concentration
EDB – 1,2-dibromoethane	ntx – no toxicity information (not selected as COPC)	VOC – volatile organic compound
HCID – hydrocarbon identification		

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Metals										
Aluminum (total)	7429-90-5	6/6	193	5,890	µg/L	na	5,890	na	no	ntx
Antimony (dissolved)	7440-36-0	5/22	0.2	0.6	µg/L	0.2 U – 0.2 U	0.6	na	no	ntx
Antimony (total)	7440-36-0	2/28	0.2	0.5	µg/L	0.2 U – 1.6 U	1.6 U	na	no	ntx
Arsenic (dissolved)	7440-38-2	22/22	0.8	32.2	µg/L	na	32.2	0.038	yes	asl
Arsenic (total)	7440-38-2	28/28	1	31.6	µg/L	na	31.6	0.038	yes	asl
Barium (dissolved)	7440-39-3	22/22	65	389	µg/L	na	389	730	no	bsl
Barium (total)	7440-39-3	28/28	65	497	µg/L	na	497	730	no	bsl
Beryllium (total)	7440-41-7	1/6	1.5	1.5	µg/L	1 U – 1 U	1.5	4	no	bsl
Cadmium (dissolved)	7440-43-9	0/22	nd	nd	µg/L	0.2 U – 0.2 U	0.2 U	na	no	ntx
Cadmium (total)	7440-43-9	4/28	0.3	1.31	µg/L	0.2 U – 0.2 U	1.31	na	no	ntx
Calcium (total)	7440-70-2	6/6	80,200	208,000	µg/L	na	208,000	na	no	ntx
Chromium (dissolved)	7440-47-3	0/22	nd	nd	µg/L	5 UJ – 5 UJ	5 U	100	no	bsl
Chromium (total)	7440-47-3	4/28	6 J	8.1	µg/L	5 U – 5 UJ	8.1	100	no	bsl
Cobalt (dissolved)	7440-48-4	9/22	3	25	µg/L	3 U – 3 U	25	na	no	ntx
Cobalt (total)	7440-48-4	9/28	3	23	µg/L	3 U – 5 U	23	na	no	ntx
Copper (dissolved)	7440-50-8	2/22	3	5	µg/L	2 U – 2 U	5	140	no	bsl
Copper (total)	7440-50-8	8/28	2	25.1	µg/L	2 U – 4 U	25.1	140	no	bsl
Iron (dissolved)	7439-89-6	22/22	1,720	64,400	µg/L	na	64,400	na	no	ntx
Iron (total)	7439-89-6	28/28	3,130	65,700	µg/L	na	65,700	na	no	ntx
Lead (dissolved)	7439-92-1	0/22	nd	nd	µg/L	1 U – 1 U	1 U	15	no	bsl
Lead (total)	7439-92-1	8/28	0.36	19.6	µg/L	1 U – 1 U	19.6	15	yes	asl
Magnesium (total)	7439-95-4	6/6	24,900	95,800	µg/L	na	95,800	na	no	ntx
Manganese (dissolved)	7439-96-5	22/22	724	6,510	µg/L	na	6,510	170	yes	asl
Manganese (total)	7439-96-5	28/28	667	7,860	µg/L	na	7,860	170	yes	asl
Mercury (dissolved)	7439-97-6	0/22	nd	nd	µg/L	0.1 U – 0.1 U	0.1 U	1.1	no	bsl
Mercury (total)	7439-97-6	1/28	0.14	0.14	µg/L	0.1 U – 0.1 U	0.14	1.1	no	bsl
Nickel (dissolved)	7440-02-0	5/22	10 J	20	µg/L	10 U – 10 U	20	73	no	bsl
Nickel (total)	7440-02-0	8/28	10	25	µg/L	10 UJ – 10 UJ	25	73	no	bsl

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Potassium (total)	7440-09-7	6/6	17,700	63,300	µg/L	na	63,300	na	no	his ^b
Selenium (dissolved)	7782-49-2	8/22	0.5	1.2	µg/L	0.5 U – 2 U	2 U	na	no	ntx
Selenium (total)	7782-49-2	10/28	0.5	4.7	µg/L	0.5 U – 2 U	4.7	na	no	ntx
Silver (total)	7440-22-4	1/6	1	1	µg/L	1 U – 1 U	1 U	18	no	bsl
Sodium (total)	7440-23-5	6/6	15,600	150,000	µg/L	na	150,000	na	no	ntx
Thallium (total)	7440-28-0	6/6	0.00894	0.0527	µg/L	na	0.0527	na	no	ntx
Vanadium (dissolved)	7440-62-2	5/22	3	9	µg/L	3 U – 3 U	9	na	no	ntx
Vanadium (total)	7440-62-2	14/28	3	54.4	µg/L	3 U – 3 U	54.4	na	no	ntx
Zinc (dissolved)	7440-66-6	2/22	40	80	µg/L	10 U – 10 U	80	na	no	ntx
Zinc (total)	7440-66-6	10/28	8.7	1,180	µg/L	4 U – 10 U	1,180	na	no	ntx
PAHs										
2-Chloronaphthalene	91-58-7	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
2-Methylnaphthalene	91-57-6	7/28	0.1 J	1.8	µg/L	0.10 U – 0.38 U	1.8	na	no	ntx
Acenaphthene	83-32-9	11/28	0.14	3.2	µg/L	0.10 U – 0.4 U	3.2	37	no	bsl
Acenaphthylene	208-96-8	0/28	nd	nd	µg/L	0.10 U – 0.4 U	0.4 U	37	no	bsl
Anthracene	120-12-7	5/28	0.10	0.24	µg/L	0.10 U – 0.4 U	0.4 U	180	no	bsl
Benzo(a)anthracene	56-55-3	0/28	nd	nd	µg/L	0.10 U – 0.4 U	0.4 U	0.029	yes	teq
Benzo(a)pyrene	50-32-8	0/28	nd	nd	µg/L	0.10 U – 0.8 U	0.8 U	0.0029	yes	teq
Benzo(b)fluoranthene	205-99-2	0/28	nd	nd	µg/L	0.10 U – 0.8 U	0.8 U	0.029	yes	teq
Benzo(g,h,i)perylene	191-24-2	0/28	nd	nd	µg/L	0.10 U – 2 U	2 U	na	no	ntx
Benzo(k)fluoranthene	207-08-9	0/28	nd	nd	µg/L	0.10 U – 0.4 U	0.4 U	0.29	yes	teq
Total benzofluoranthenes	56832-73-6	0/28	nd	nd	µg/L	0.10 U – 0.8 U	0.8 U	na	no	ntx
Chrysene	218-01-9	0/28	nd	nd	µg/L	0.10 U – 0.4 U	0.4 U	2.9	no	teq
Dibenzo(a,h)anthracene	53-70-3	0/28	nd	nd	µg/L	0.10 U – 4 U	4 U	0.0029	yes	teq
Dibenzofuran	132-64-9	2/28	0.16	0.18	µg/L	0.10 U – 0.4 U	0.4 U	na	no	ntx
Fluoranthene	206-44-0	3/28	0.12	0.64	µg/L	0.10 U – 0.4 U	0.64	150	no	bsl
Fluorene	86-73-7	9/28	0.13	1.9	µg/L	0.10 U – 0.4 U	1.9	24	no	bsl
Indeno(1,2,3-cd)pyrene	193-39-5	0/28	nd	nd	µg/L	0.10 U – 4 U	4 U	0.029	yes	teq
Naphthalene	91-20-3	7/28	0.10	1.5	µg/L	0.10 U – 0.4 U	1.5	0.12	yes	asl
Phenanthrene	85-01-8	3/28	0.13	0.25	µg/L	0.10 U – 0.4 U	0.4 U	na	no	ntx

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Pyrene	129-00-0	3/28	0.12 J	0.53	µg/L	0.10 U – 0.4 U	0.53	110	no	bsl
Total HPAHs	na	4/28	0.12	1.17	µg/L	0.10 U – 4 U	4 U	na	no	ntx
Total LPAHs	na	12/28	0.10	5.1	µg/L	0.10 U – 0.4 U	5.1	na	no	ntx
cPAH TEQ	na	0/28	nd	nd	µg/L	0.0910 U – 1.50 U	1.50 U	0.0029	yes	asl
Total PAHs	na	12/28	0.10	6.3	µg/L	0.10 U – 4 U	6.3	na	no	ntx
Phthalates										
Bis(2-ethylhexyl)phthalate	117-81-7	5/6	0.59	1.8	µg/L	0.38 U – 0.38 U	1.8	4.1	no	bsl
Butyl benzyl phthalate	85-68-7	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
Diethyl phthalate	84-66-2	1/6	0.25 J	0.25 J	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
Dimethyl phthalate	131-11-3	0/6	nd	nd	µg/L	0.74 U – 0.8 U	0.8 U	na	no	ntx
Di-n-butyl phthalate	84-74-2	2/6	0.1 J	0.15 J	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
Di-n-octyl phthalate	117-84-0	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
Other SVOCs										
1,2,4-Trichlorobenzene	120-82-1	0/28	nd	nd	µg/L	0.50 U – 5.0 U	5.0 U	na	no	ntx
1,2-Dichlorobenzene	95-50-1	2/28	0.22 J	0.50	µg/L	0.20 U – 1.0 U	1 U	5	no	bsl
1,3-Dichlorobenzene	541-73-1	2/28	0.2 J	0.35 J	µg/L	0.20 U – 1.0 U	1 U	1.5	no	bsl
1,4-Dichlorobenzene	106-46-7	4/28	0.18 J	1.4	µg/L	0.20 U – 1.0 U	1.4	0.48	yes	asl
2,4,5-Trichlorophenol	95-95-4	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
2,4,6-Trichlorophenol	88-06-2	0/6	nd	nd	µg/L	0.74 U – 0.8 U	0.8 U	5.2	no	bsl
2,4-Dichlorophenol	120-83-2	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
2,4-Dimethylphenol	105-67-9	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
2,4-Dinitrophenol	51-28-5	0/6	nd	nd	µg/L	7.4 U – 8 U	8 U	na	no	ntx
2,4-Dinitrotoluene	121-14-2	0/6	nd	nd	µg/L	0.74 U – 0.8 U	0.8 U	na	no	ntx
2,6-Dinitrotoluene	606-20-2	0/6	nd	nd	µg/L	3.7 U – 4 U	4 U	3.7	yes	asl
2-Chlorophenol	95-57-8	1/6	0.97	0.97	µg/L	0.37 U – 0.38 U	0.97	na	no	ntx
2-Methylphenol	95-48-7	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
2-Nitroaniline	88-74-4	0/6	nd	nd	µg/L	0.74 U – 0.8 U	0.8 U	na	no	ntx
2-Nitrophenol	88-75-5	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
3,3'-Dichlorobenzidine	91-94-1	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	0.13	yes	asl
3-Nitroaniline	99-09-2	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
4,6-Dinitro-o-cresol	534-52-1	0/6	nd	nd	µg/L	3.7 U – 4 U	4 U	na	no	ntx
4-Bromophenyl phenyl ether	101-55-3	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
4-Chloro-3-methylphenol	59-50-7	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
4-Chloroaniline	106-47-8	0/6	nd	nd	µg/L	0.74 U – 0.8 U	0.8 U	na	no	ntx
4-Chlorophenyl phenyl ether	7005-72-3	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
4-Methylphenol	106-44-5	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
4-Nitroaniline	100-01-6	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
4-Nitrophenol	100-02-7	0/6	nd	nd	µg/L	3.7 U – 4 U	4 U	na	no	ntx
Acetophenone	98-86-2	1/6	0.16 J	0.16 J	µg/L	0.37 U – 0.38 U	0.38 U	na	no	ntx
Atrazine	1912-24-9	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
Benzaldehyde	100-52-7	2/6	0.12 J	0.13 J	µg/L	0.37 UJ – 0.4 UJ	0.4 UJ	na	no	ntx
Biphenyl	92-52-4	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
bis(2-chloroethoxy)methane	111-91-1	0/6	nd	nd	µg/L	0.37 U – 119 U	119 U	na	no	ntx
bis(2-chloroethyl)ether	111-44-4	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
bis(2-chloroisopropyl)ether	108-60-1	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
Caprolactam	105-60-2	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
Carbazole	86-74-8	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
Hexachlorobenzene (dissolved)	118-74-1	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.035	no	bsl
Hexachlorobenzene	118-74-1	0/28	nd	nd	µg/L	0.0050 U – 0.4 U	0.4 U	0.035	yes	asl
Hexachlorobutadiene (dissolved)	87-68-3	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	na	no	ntx
Hexachlorobutadiene	87-68-3	0/28	nd	nd	µg/L	0.0050 U – 0.4 U	0.4 U	na	no	ntx
Hexachlorocyclopentadiene	77-47-4	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	na	no	ntx
Hexachloroethane	67-72-1	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	4.1	no	bsl
Isophorone	78-59-1	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
Nitrobenzene	98-95-3	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
n-Nitroso-di-n-propylamine	621-64-7	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
n-Nitrosodiphenylamine	86-30-6	0/6	nd	nd	µg/L	0.37 U – 0.4 U	0.4 U	na	no	ntx
Pentachlorophenol	87-86-5	0/6	nd	nd	µg/L	1.8 U – 2 U	2 U	0.47	yes	asl
Phenol	108-95-2	5/6	0.095 J	0.37 J	µg/L	0.38 U – 0.38 U	0.38 U	na	no	ntx

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
PCBs										
Aroclor-1016	12674-11-2	0/28	nd	nd	µg/L	0.10 U – 0.48 U	0.48 U	na	no	sum
Aroclor-1221	11104-28-2	0/28	nd	nd	µg/L	0.10 U – 0.96 U	0.96 U	na	no	sum
Aroclor-1232	11141-16-5	0/28	nd	nd	µg/L	0.10 U – 0.48 U	0.48 U	na	no	sum
Aroclor-1242	53469-21-9	0/28	nd	nd	µg/L	0.10 U – 0.48 U	0.48 U	na	no	sum
Aroclor-1248	12672-29-6	0/28	nd	nd	µg/L	0.10 U – 0.48 U	0.48 U	na	no	sum
Aroclor-1254	11097-69-1	0/28	nd	nd	µg/L	0.10 U – 0.48 U	0.48 U	na	no	sum
Aroclor-1260	11096-82-5	0/28	nd	nd	µg/L	0.10 U – 0.48 U	0.48 U	na	no	sum
Total PCBs	1336-36-3	0/28	nd	nd	µg/L	0.10 U – 0.96 U	0.96 U	0.028	yes	asl
Pesticides										
2,4'-DDD (dissolved)	53-19-0	1/4	0.014	0.014	µg/L	0.010 U – 0.010 U	0.014	na	no	sum
2,4'-DDD	53-19-0	6/22	0.0063 J	0.032	µg/L	0.010 U – 0.010 U	0.032	na	no	sum
2,4'-DDE (dissolved)	3424-82-6	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	sum
2,4'-DDE	3424-82-6	0/22	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	sum
2,4'-DDT (dissolved)	789-02-6	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	sum
2,4'-DDT	789-02-6	0/22	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	sum
4,4'-DDD (dissolved)	72-54-8	2/4	0.011	0.059 J	µg/L	0.010 U – 0.010 U	0.059 J	0.24	no	sum
4,4'-DDD	72-54-8	12/28	0.0071 J	0.24 J	µg/L	0.010 U – 0.019 U	0.24 J	0.24	no	sum
4,4'-DDE (dissolved)	72-55-9	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.17	no	sum
4,4'-DDE	72-55-9	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	0.17	no	sum
4,4'-DDT (dissolved)	50-29-3	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.17	no	sum
4,4'-DDT	50-29-3	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	0.17	no	sum
Total DDTs (dissolved)	na	2/4	0.011	0.073 J	µg/L	0.010 U – 0.010 U	0.073 J	0.17	no	bsl
Total DDTs	na	12/28	0.0071 J	0.24 J	µg/L	0.010 U – 0.019 U	0.24 J	0.17	yes	asl
Aldrin (dissolved)	309-00-2	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.0033	yes	asl
Aldrin	309-00-2	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	0.0033	yes	asl
Dieldrin (dissolved)	60-57-1	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.0035	yes	asl
Dieldrin	60-57-1	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	0.0035	yes	asl
Total aldrin/dieldrin (dissolved)	na	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	ntx
Total aldrin/dieldrin	na	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	na	no	ntx

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
alpha-BHC (dissolved)	319-84-6	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.009	no	bsl
alpha-BHC	319-84-6	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	0.009	yes	asl
beta-BHC (dissolved)	319-85-7	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	na	no	ntx
beta-BHC	319-85-7	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	na	no	ntx
gamma-BHC (dissolved)	58-89-9	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.044	no	bsl
gamma-BHC	58-89-9	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	0.044	no	bsl
delta-BHC (dissolved)	319-86-8	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	na	no	ntx
delta-BHC	319-86-8	0/28	nd	nd	µg/L	0.0050 U – 0.043 U	0.043 U	na	no	ntx
alpha-Chlordane (dissolved)	5103-71-9	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.16	no	bsl
alpha-Chlordane	5103-71-9	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	0.16	no	bsl
gamma-Chlordane (dissolved)	5103-74-2	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	na	no	ntx
gamma-Chlordane	5103-74-2	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	na	no	ntx
Total chlordane (dissolved)	57-74-9	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.16	no	bsl
Total chlordane	57-74-9	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	0.16	no	bsl
alpha-Endosulfan (dissolved)	959-98-8	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	22	no	bsl
alpha-Endosulfan	959-98-8	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	22	no	bsl
beta-Endosulfan (dissolved)	33213-65-9	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	22	no	bsl
beta-Endosulfan	33213-65-9	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	22	no	bsl
Endosulfan sulfate (dissolved)	1031-07-8	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	22	no	bsl
Endosulfan sulfate	1031-07-8	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	22	no	bsl
Endrin (dissolved)	72-20-8	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	1.1	no	bsl
Endrin	72-20-8	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	1.1	no	bsl
Endrin aldehyde (dissolved)	7421-93-4	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	1.1	no	bsl
Endrin aldehyde	7421-93-4	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	1.1	no	bsl
Endrin ketone (dissolved)	53494-70-5	0/4	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	1.1	no	bsl
Endrin ketone	53494-70-5	0/28	nd	nd	µg/L	0.010 U – 0.019 U	0.019 U	1.1	no	bsl
Heptachlor (dissolved)	76-44-8	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.013	no	bsl
Heptachlor	76-44-8	0/28	nd	nd	µg/L	0.0050 U – 0.024 U	0.024 U	0.013	yes	asl
Heptachlor epoxide (dissolved)	1024-57-3	0/4	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.0062	no	bsl
Heptachlor epoxide	1024-57-3	0/28	nd	nd	µg/L	0.0050 U – 0.019 U	0.019 U	0.0062	yes	asl

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Methoxychlor (dissolved)	72-43-5	0/4	nd	nd	µg/L	0.050 U – 0.050 U	0.050 U	na	no	ntx
Methoxychlor	72-43-5	0/28	nd	nd	µg/L	0.018 U – 0.050 U	0.050 U	na	no	ntx
Toxaphene (dissolved)	8001-35-2	0/4	nd	nd	µg/L	0.50 U – 0.50 U	0.50 U	0.052	yes	asl
Toxaphene	8001-35-2	0/28	nd	nd	µg/L	0.50 U – 4.8 U	4.8 U	0.052	yes	asl
VOCs										
1,1,1,2-Tetrachloroethane	630-20-6	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
1,1,1-Trichloroethane	71-55-6	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	84	no	bsl
1,1,2,2-Tetrachloroethane	79-34-5	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
1,1,2-Trichloroethane	79-00-5	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	2.4	no	bsl
1,1,2-Trichlorotrifluoroethane	76-13-1	0/28	nd	nd	µg/L	0.20 U – 2.0 U	2.0 U	na	no	ntx
1,1-Dichloroethane	75-34-3	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	2	no	bsl
1,1-Dichloroethene	75-35-4	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	7	no	bsl
1,1-Dichloropropene	563-58-6	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
1,2,3-Trichlorobenzene	87-61-6	0/22	nd	nd	µg/L	0.50 U – 5.0 U	5.0 U	na	no	ntx
1,2,3-Trichloropropane	96-18-4	0/22	nd	nd	µg/L	0.50 U – 2.0 U	2.0 U	na	no	ntx
1,2,4-Trimethylbenzene	95-63-6	2/22	3.7	7.2	µg/L	0.20 U – 1.0 U	7.2	1.2	yes	asl
1,2-Dibromo-3-chloropropane	96-12-8	0/28	nd	nd	µg/L	0.50 U – 5.0 U	5.0 U	na	no	ntx
1,2-Dibromoethane (EDB)	106-93-4	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	0.0057	yes	asl
1,2-Dichloroethane	107-06-2	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	0.13	yes	asl
1,2-Dichloroethene (total)	540-59-0	0/6	nd	nd	µg/L	1 U – 1 U	1 U	na	no	ntx
1,2-Dichloropropane	78-87-5	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	na	no	ntx
1,3,5-Trimethylbenzene	108-67-8	3/22	1.5	3.0	µg/L	0.20 U – 1.0 U	3.0	1.2	yes	asl
1,3-Dichloropropane	142-28-9	0/22	nd	nd	µg/L	0.20 U – 5.0 U	5.0 U	na	no	ntx
2,2-Dichloropropane	594-20-7	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
2-Chlorotoluene	95-49-8	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
2-Hexanone	591-78-6	0/28	nd	nd	µg/L	2 U – 5.0 U	5.0 U	na	no	ntx
4-Chlorotoluene	106-43-4	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
Acetone	67-64-1	11/28	4.4	18	µg/L	2 U – 15.6 U	18	na	no	ntx
Benzene	71-43-2	8/28	0.80	140	µg/L	0.20 U – 6.2 U	140	0.35	yes	asl
Bromobenzene	108-86-1	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Bromochloromethane	74-97-5	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
Bromodichloromethane	75-27-4	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	0.18	yes	asl
Bromoform	75-25-2	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	7.2	no	bsl
Bromomethane	74-83-9	0/28	nd	nd	µg/L	0.50 U – 1.0 U	1 U	0.85	yes	asl
Carbon disulfide	75-15-0	0/28	nd	nd	µg/L	0.20 U – 2 U	2 U	na	no	ntx
Carbon tetrachloride	56-23-5	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	0.17	yes	asl
Chlorobenzene	108-90-7	15/28	0.2 J	130	µg/L	0.20 U – 1.0 U	130	9	yes	asl
Chloroethane	75-00-3	0/28	nd	nd	µg/L	0.20 U – 2 U	2 U	3.9	no	bsl
Chloroform	67-66-3	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	0.18	yes	asl
Chloromethane	74-87-3	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	2.3	no	bsl
cis-1,2-Dichloroethene	156-59-2	1/28	0.23 J	0.23 J	µg/L	0.20 U – 1.0 U	1 U	6.1	no	bsl
cis-1,3-Dichloropropene	10061-01-5	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
Cyclohexane	110-82-7	0/6	nd	nd	µg/L	1 U – 1 U	1 U	na	no	ntx
p-Cymene	99-87-6	1/22	0.30	0.30	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
Dibromochloromethane	124-48-1	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
Dibromomethane	74-95-3	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
Dichlorodifluoromethane	75-71-8	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	na	no	ntx
Dichloromethane	75-09-2	0/28	nd	nd	µg/L	0.50 U – 2.0 U	2.0 U	4.1	no	bsl
Ethylbenzene	100-41-4	1/28	1.2	1.2	µg/L	0.20 U – 1.0 U	1.2	1.2	no	bsl
Isopropylbenzene	98-82-8	4/28	0.039 J	8.3	µg/L	0.20 U – 1.0 U	8.3	66	no	bsl
Methyl acetate	79-20-9	0/6	nd	nd	µg/L	1 U – 1 U	1 U	na	no	ntx
Methyl ethyl ketone	78-93-3	0/28	nd	nd	µg/L	2 U – 5.0 U	5.0 U	na	no	ntx
Methyl isobutyl ketone	108-10-1	0/28	nd	nd	µg/L	2 U – 5.0 U	5.0 U	na	no	ntx
Methylcyclohexane	108-87-2	0/6	nd	nd	µg/L	1 U – 1 U	1 U	na	no	ntx
n-Butylbenzene	104-51-8	1/22	0.50	0.50	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
n-Propylbenzene	103-65-1	4/22	1.8	11	µg/L	0.20 U – 1.0 U	11	6.1	yes	asl
sec-Butylbenzene	135-98-8	1/22	0.40	0.40	µg/L	0.20 U – 1.0 U	1.0 U	6.1	no	bsl
Styrene	100-42-5	1/28	0.24 J	0.24 J	µg/L	0.20 U – 1.0 U	1 U	100	no	bsl
tert-Butyl methyl ether	1634-04-4	14/28	1.4	160	µg/L	0.50 U – 1.0 U	160	11	yes	asl
tert-Butylbenzene	98-06-6	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx

Table 2: Occurrence and selection of COPCs for Groundwater in the Industrial (Construction/Trenching) Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Worker Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Tetrachloroethene	127-18-4	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	na	no	ntx
Toluene	108-88-3	2/28	0.60	4.8	µg/L	0.20 U – 1.0 U	4.8	230	no	bsl
trans-1,2-Dichloroethene	156-60-5	0/22	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	11	no	bsl
trans-1,3-Dichloropropene	10061-02-6	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1.0 U	na	no	ntx
Trichloroethene	79-01-6	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	0.029	yes	asl
Trichlorofluoromethane	75-69-4	0/28	nd	nd	µg/L	0.20 U – 1.0 U	1 U	130	no	bsl
Vinyl acetate	108-05-4	0/22	nd	nd	µg/L	1.0 U – 5.0 U	5.0 U	na	no	ntx
Vinyl chloride	75-01-4	1/28	0.22 J	0.22 J	µg/L	0.20 U – 1.0 U	1 U	0.025	yes	asl
o-Xylene	95-47-6	2/28	4.0	6.0	µg/L	0.20 U – 1.0 U	6.0	21	no	sum
m,p-Xylene	108383/106423	3/28	1.4	10	µg/L	0.40 U – 2.0 U	10	21	no	sum
Total xylenes	1330-20-7	3/28	1.4	20	µg/L	0.40 U – 2.0 U	20	21	no	bsl
Petroleum^c										
TPH - Gasoline range	na	5/22	0.27	0.81	mg/L	0.25 U – 0.25 U	0.81	4	no	bsl
TPH - Diesel range	na	1/22	0.26 J	0.26 J	mg/L	0.25 U – 0.25 U	0.26 J	3.5	no	bsl
TPH - Motor oil range	na	0/22	nd	nd	mg/L	0.50 U – 0.50 U	0.50 U	4.9	no	bsl

^a The worker water RSL is the lowest of EPA water screening levels (2009d), EPA MCL or non-zero MCLGs (2009a), and DEQ human health occupational RBCs for the following four exposure pathways: ingestion and inhalation from tap water, volatilization to outdoor air, vapor intrusion into buildings, and leaching to groundwater during excavation (DEQ 2007). For TPHs, the screening level is the lowest occupational DEQ RBC (2003).

^b Potassium was analyzed only in historical data, but not in samples collected in the RI/FS sampling effort because potassium is an essential nutrient and is not expected to be toxic to humans based on the daily reference intake for potassium of 4.7 g/day (Institute of Medicine 2004).

^c Aromatic and aliphatic TPHs were assumed to be equal to 15% and 85% of the TPH total for each of the three fractions (gasoline, diesel, and motor oil) based on ATSDR (1999). For the purposes of this HHRA, only aliphatic TPHs were carried forward as COPCs when above screening levels because the components of the aromatic TPHs (e.g., various PAHs and VOCs) were already assessed and thus the assessment of aromatic TPHs as an additional chemical group would double count risks.

asl – above screening level (selected as COPC)

BHC – benzene hexachloride

bsl – below screening level

COPC – contaminant of potential concern

CAS – chemical abstracts service

cPAH – carcinogenic PAH

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

EDB – 1,2-dibromoethane

HCID – hydrocarbon identification

HPAH – high-molecular-weight PAH

J – estimated concentration

LPAH – low-molecular-weight PAH

MCL – maximum contaminant level

MCLG – maximum contaminant level goals

na – not available

N – tentative identification

ND – not detected

ntx – no toxicity information (not selected as COPC)

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RBC – risk-based concentration

RSL – regional screening level

sum – chemical included in sum and is not evaluated separately

SVOC – semivolatile organic compound

teq – chemical included in TEQ calculation and is not evaluated separately

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

U – not detected at given concentration

VOC – volatile organic compound

Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Metals								na			
Aluminum	7429-90-5	15/15	5,280	12,100	mg/kg dw	na	12,100	na	990,000	no	bsl
Antimony	7440-36-0	4/69	0.7 J	8.4 J	mg/kg dw	0.2 UJ – 4.5 U	8.4 J	4	41	no	bsl
Arsenic	7440-38-2	69/69	0.7	53.1	mg/kg dw	na	53.1	7	1.6	yes	asl
Barium	7440-39-3	69/69	36.5	1,170 J	mg/kg dw	na	1,170 J	na	6,200	no	bsl
Beryllium	7440-41-7	15/15	0.29	0.601	mg/kg dw	na	0.601	na	61	no	bsl
Cadmium	7440-43-9	46/69	0.2	4	mg/kg dw	0.2 UJ – 0.3 U	4	1	80	no	bsl
Calcium	7440-70-2	15/15	3,040	18,500	mg/kg dw	na	18,500	na	na	no	ntx
Chromium	7440-47-3	69/69	4.0	111	mg/kg dw	na	111	42	180	no	bsl
Cobalt	7440-48-4	69/69	4.1 J	32	mg/kg dw	na	32	na	30	yes	asl
Copper	7440-50-8	69/69	9.23	1,240 J	mg/kg dw	na	1,240 J	36	1100	yes	asl
Iron	7439-89-6	15/15	1,400	56,500	mg/kg dw	na	56,500	na	720,000	no	bsl
Lead	7439-92-1	69/69	3	337	mg/kg dw	na	337	17	30	yes	asl
Magnesium	7439-95-4	15/15	2,880	5,370	mg/kg dw	na	5,370	na	na	no	ntx
Manganese	7439-96-5	15/15	158	1,090	mg/kg dw	na	1,090	na	1,400	no	bsl
Mercury	7439-97-6	37/69	0.03	6.69	mg/kg dw	0.04 UJ – 0.07 U	6.69	0.07	9.3	no	bsl
Nickel	7440-02-0	69/69	4	50 J	mg/kg dw	na	50 J	38	620	no	bsl
Potassium	7440-09-7	15/15	576	1,720	mg/kg dw	na	1,720	na	72	no	his ^c
Selenium	7782-49-2	6/69	0.1	1.1	mg/kg dw	0.1 U – 3 U	3 U	2	510	no	bsl
Silver	7440-22-4	14/15	0.42	3.16	mg/kg dw	0.4 U – 0.4 U	3.16	na	150	no	bsl
Sodium	7440-23-5	15/15	286	850	mg/kg dw	na	850	na	na	no	ntx
Thallium	7440-28-0	0/15	nd	nd	mg/kg dw	0.3 U – 0.75 U	0.75 U	na	6.6	no	bsl
Vanadium	7440-62-2	69/69	29.4 J	165	mg/kg dw	na	165	na	520	no	bsl
Zinc	7440-66-6	69/69	35	748	mg/kg dw	na	748	86	310,000	no	bsl
PAHs											
2-Chloronaphthalene	91-58-7	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	82,000,000	no	bsl
2-Methylnaphthalene	91-57-6	60/73	13	29,000	µg/kg dw	5.0 U – 131 U	29,000	na	4,100,000	no	bsl
Acenaphthene	83-32-9	35/73	5.3	28,000	µg/kg dw	4.6 U – 883 U	28,000	na	1,600,000	no	bsl
Acenaphthylene	208-96-8	15/73	5.3	836 J	µg/kg dw	4.6 U – 735 U	836 J	na	3,300,000	no	bsl
Anthracene	120-12-7	61/73	7.9	110,000	µg/kg dw	5.0 U – 735 U	110,000	na	9,000,000	no	bsl
Benzo(a)anthracene	56-55-3	60/73	6.9	8,800	µg/kg dw	9.7 U – 883 U	8,800	na	2,100	yes	teq
Benzo(a)pyrene	50-32-8	65/73	9.9	3,800	µg/kg dw	15 U – 265 U	3,800	na	210	yes	teq
Benzo(b)fluoranthene	205-99-2	63/73	14	3,000	µg/kg dw	15 U – 1,470 U	3,000	na	2,100	yes	teq
Benzo(g,h,i)perylene	191-24-2	65/73	5.7	3,390 J	µg/kg dw	14 U – 665 U	3,390 J	na	na	no	ntx

Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Benzo(k)fluoranthene	207-08-9	61/73	6.4	3,500	µg/kg dw	15 U – 883 U	3,500	na	21,000	no	teq
Total benzofluoranthenes	56832-73-6	64/73	11 J	6,400	µg/kg dw	15 U – 1,470 U	6,400	na	na	no	ntx
Chrysene	218-01-9	68/73	11	13,000	µg/kg dw	37 U – 735 U	13,000	na	210,000	no	teq
Dibenzo(a,h)anthracene	53-70-3	27/73	9.4	420	µg/kg dw	4.6 U – 8,830 U	8,830 U	na	210	yes	teq
Dibenzofuran	132-64-9	47/73	5.1	18,000	µg/kg dw	5.0 U – 735 U	18,000	na	na	no	ntx
Fluoranthene	206-44-0	67/73	9.7	35,000	µg/kg dw	15 U – 131 U	35,000	na	890,000	no	bsl
Fluorene	86-73-7	40/73	7.2	40,000	µg/kg dw	4.6 U – 735 U	40,000	na	1,200,000	no	bsl
Indeno(1,2,3-cd)pyrene	193-39-5	58/73	8.6	3,830 J	µg/kg dw	4.7 U – 1,330 U	3,830 J	na	2,100	yes	teq
Naphthalene	91-20-3	52/73	5.8	19,000	µg/kg dw	5.0 U – 242 U	19,000	na	410	yes	asl
Phenanthrene	85-01-8	67/73	7.9	77,000	µg/kg dw	9.7 U – 131 U	77,000	na	na	no	ntx
Pyrene	129-00-0	70/73	16	31,000	µg/kg dw	20 U – 120 U	31,000	na	670,000	no	bsl
Total HPAHs	na	71/73	36 J	99,000	µg/kg dw	62 U – 1,200 U	99,000	na	na	no	ntx
Total LPAHs	na	67/73	7.9	260,000	µg/kg dw	9.7 U – 131 U	260,000	na	na	no	ntx
cPAH TEQ	na	69/73	14.0	5,200	µg/kg dw	33.0 U – 450 U	5,200	na	210	yes	asl
Total PAHs	na	72/73	36 J	360,000	µg/kg dw	1,200 U – 1,200 U	360,000	na	na	no	ntx
Phthalates											
Bis(2-ethylhexyl)phthalate	117-81-7	31/37	11 J	5,730	µg/kg dw	56 U – 133 U	5,730	na	120,000	no	bsl
Butyl benzyl phthalate	85-68-7	7/37	190	3,140 J	µg/kg dw	20 U – 3,680 U	3,680 U	na	910,000	no	bsl
Diethyl phthalate	84-66-2	1/37	184 J	184 J	µg/kg dw	20 U – 883 U	883 U	na	4.9 x 10 ⁸	no	bsl
Dimethyl phthalate	131-11-3	0/37	nd	nd	µg/kg dw	20 U – 1,770 U	1,770 U	na	na	no	ntx
Di-n-butyl phthalate	84-74-2	2/37	59	194	µg/kg dw	20 U – 883 U	883 U	na	6,200,000	no	bsl
Di-n-octyl phthalate	117-84-0	0/37	nd	nd	µg/kg dw	20 U – 4,420 U	4,420 U	na	na	no	ntx
Other SVOCs											
1,2,4-Trichlorobenzene	120-82-1	2/69	7.2 J	24 J	µg/kg dw	2.2 U – 4,000 U	4,000 U	na	400,000	no	bsl
1,2-Dichlorobenzene	95-50-1	11/68	1.3 JN	980	µg/kg dw	0.9 U – 440 U	980	na	3,800	no	bsl
1,3-Dichlorobenzene	541-73-1	4/67	1.4 J	2.7 J	µg/kg dw	0.9 U – 810 U	810 U	na	1,100	no	bsl
1,4-Dichlorobenzene	106-46-7	13/68	2.2	99	µg/kg dw	0.9 U – 810 U	810 U	na	540	no	ife
2,4,5-Trichlorophenol	95-95-4	0/37	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	6,200,000	no	bsl
2,4,6-Trichlorophenol	88-06-2	0/37	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	13,000	no	bsl
2,4-Dichlorophenol	120-83-2	0/37	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	180,000	no	bsl
2,4-Dimethylphenol	105-67-9	3/37	70	480	µg/kg dw	20 U – 883 U	883 U	na	1,200,000	no	bsl
2,4-Dinitrophenol	51-28-5	0/35	nd	nd	µg/kg dw	200 U – 17,700 U	17,700 U	na	120,000	no	bsl
2,4-Dinitrotoluene	121-14-2	0/37	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	5,500	no	bsl
2,6-Dinitrotoluene	606-20-2	0/37	nd	nd	µg/kg dw	98 U – 8,830 U	8,830 U	na	1,700	yes	asl
2-Chlorophenol	95-57-8	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	510,000	no	bsl

Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
2-Methylphenol	95-48-7	2/37	163	518	µg/kg dw	20 U – 883 U	883 U	na	3,100,000	no	bsl
2-Nitroaniline	88-74-4	0/37	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	180,000	no	bsl
2-Nitrophenol	88-75-5	0/37	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	na	no	ntx
3,3'-Dichlorobenzidine	91-94-1	0/36	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	200	yes	asl
3-Nitroaniline	99-09-2	0/37	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	na	no	ntx
4,6-Dinitro-o-cresol	534-52-1	0/37	nd	nd	µg/kg dw	200 U – 8,830 U	8,830 U	na	6,200	no	ife
4-Bromophenyl phenyl ether	101-55-3	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	na	no	ntx
4-Chloro-3-methylphenol	59-50-7	0/37	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	na	no	ntx
4-Chloroaniline	106-47-8	0/37	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	8,600	no	bsl
4-Chlorophenyl phenyl ether	7005-72-3	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	na	no	ntx
4-Methylphenol	106-44-5	7/37	25	1,240	µg/kg dw	20 U – 883 U	1,240	na	310,000	no	bsl
4-Nitroaniline	100-01-6	0/37	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	86,000	no	bsl
4-Nitrophenol	100-02-7	0/37	nd	nd	µg/kg dw	98 U – 8,830 U	8,830 U	na	na	no	ntx
Acetophenone	98-86-2	3/15	68.2 J	630 J	µg/kg dw	119 U – 1,730 U	1,730 U	na	1.0 x 10 ⁸	no	bsl
Aniline	62-53-3	0/21	nd	nd	µg/kg dw	20 U – 440 U	440 U	na	300,000	no	bsl
Atrazine	1912-24-9	0/15	nd	nd	µg/kg dw	596 U – 4,420 U	4,420 U	na	7,500	no	bsl
Benzaldehyde	100-52-7	3/14	37.2 J	1,080 J	µg/kg dw	119 UJ – 288 UJ	1,080 J	na	1.0 x 10 ⁸	no	bsl
Benzoic acid	65-85-0	4/22	250	820	µg/kg dw	200 U – 4,400 U	4,400 U	na	2.5 x 10 ⁹	no	bsl
Benzyl alcohol	100-51-6	2/22	17 J	170	µg/kg dw	20 U – 440 U	440 U	na	3.1 x 10 ⁸	no	bsl
Biphenyl	92-52-4	6/15	44.7 J	1,000	µg/kg dw	119 U – 735 U	1,000	na	5.1 x 10 ⁷	no	bsl
bis(2-chloroethoxy)methane	111-91-1	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	180,000	no	bsl
bis(2-chloroethyl)ether	111-44-4	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	900	no	bsl
bis(2-chloroisopropyl)ether	108-60-1	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	17,000	no	bsl
Caprolactam	105-60-2	0/15	nd	nd	µg/kg dw	596 U – 4,420 U	4,420 U	na	3.1 x 10 ⁸	no	bsl
Carbazole	86-74-8	8/37	12 J	940	µg/kg dw	20 U – 883 U	940	na	na	no	ntx
Hexachlorobenzene	118-74-1	2/72	42	230	µg/kg dw	0.97 U – 4,800 U	4,800 U	na	1,100	no	ife
Hexachlorobutadiene	87-68-3	0/72	nd	nd	µg/kg dw	0.97 U – 4,000 U	4,000 U	na	22,000	no	bsl
Hexachlorocyclopentadiene	77-47-4	0/36	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	370,000	no	bsl
Hexachloroethane	67-72-1	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	16,000	no	bsl
Isophorone	78-59-1	0/37	nd	nd	µg/kg dw	20 U – 883 U	883 U	na	1,800,000	no	bsl
Nitrobenzene	98-95-3	0/37	nd	nd	µg/kg dw	20 U – 2,000 U	2,000 U	na	22,000	no	bsl
n-Nitroso-di-n-propylamine	621-64-7	0/37	nd	nd	µg/kg dw	98 U – 2,200 U	2,200 U	na	250	yes	asl
n-Nitrosodiphenylamine	86-30-6	0/37	nd	nd	µg/kg dw	20 U – 2,500 U	2,500 U	na	350,000	no	bsl
Pentachlorophenol	87-86-5	0/37	nd	nd	µg/kg dw	98 U – 4,420 U	4,420 U	na	3,500	no	ife
Phenol	108-95-2	7/37	53	825	µg/kg dw	20 U – 440 U	825	na	1.8 x 10 ⁸	no	bsl

Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
PCBs											
Aroclor-1016	12674-11-2	0/71	nd	nd	µg/kg dw	15 U – 360 U	360 U	na	21,000	no	sum
Aroclor-1221	11104-28-2	0/71	nd	nd	µg/kg dw	30 U – 360 U	360 U	na	620	no	sum
Aroclor-1232	11141-16-5	0/71	nd	nd	µg/kg dw	15 U – 360 U	360 U	na	620	no	sum
Aroclor-1242	53469-21-9	0/71	nd	nd	µg/kg dw	15 U – 360 U	360 U	na	740	no	sum
Aroclor-1248	12672-29-6	26/71	46	14,000	µg/kg dw	15 U – 180 U	14,000	na	740	no	sum
Aroclor-1254	11097-69-1	15/71	74	8,200	µg/kg dw	15 U – 1,700 U	8,200	na	740	no	sum
Aroclor-1260	11096-82-5	56/71	4.9 J	9,900	µg/kg dw	17 U – 160 U	9,900	na	740	no	sum
Total PCBs	1336-36-3	59/71	4.9 J	32,000	µg/kg dw	32 U – 160 U	32,000	na	740	yes	asl
Pesticides											
2,4'-DDD	53-19-0	44/57	7.4	12,000	µg/kg dw	2.0 U – 540 U	12,000	na	na	no	sum
2,4'-DDE	3424-82-6	1/57	7.0	7.0	µg/kg dw	2.0 U – 9,600 U	9,600 U	na	na	no	sum
2,4'-DDT	789-02-6	5/57	3.0 J	920	µg/kg dw	2.0 U – 9,600 U	9,600 U	na	na	no	sum
4,4'-DDD	72-54-8	66/72	5.0	64,000	µg/kg dw	0.6 U – 130 U	64,000	na	7,200	no	sum
4,4'-DDE	72-55-9	29/72	1.6	5,200 J	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	5,100	no	sum
4,4'-DDT	50-29-3	33/72	5.6	8,400	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,000	no	sum
Total DDTs	na	68/72	5.0	78,000 J	µg/kg dw	0.6 U – 130 U	78,000 J	na	7,000	yes	asl
Aldrin	309-00-2	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	100	yes	asl
Dieldrin	60-57-1	0/72	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	110	yes	asl
Total aldrin/dieldrin	na	0/72	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	na	no	ntx
alpha-BHC	319-84-6	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	35	yes	asl
beta-BHC	319-85-7	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	960	no	ife
gamma-BHC	58-89-9	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	100	yes	asl
delta-BHC	319-86-8	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
alpha-Chlordane	5103-71-9	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
gamma-Chlordane	5103-74-2	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
Total chlordane	57-74-9	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	6,500	no	bsl
alpha-Endosulfan	959-98-8	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	140,000	no	bsl
beta-Endosulfan	33213-65-9	0/72	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	140,000	no	bsl
Endosulfan sulfate	1031-07-8	0/72	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	140,000	no	bsl
Endrin	72-20-8	1/72	2.6	2.6	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,100	no	ife
Endrin aldehyde	7421-93-4	0/72	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,100	no	ife
Endrin ketone	53494-70-5	0/72	nd	nd	µg/kg dw	0.6 U – 9,600 U	9,600 U	na	7,100	no	ife
Heptachlor	76-44-8	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	380	no	ife
Heptachlor epoxide	1024-57-3	0/72	nd	nd	µg/kg dw	0.6 U – 4,800 U	4,800 U	na	190	yes	asl

Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Methoxychlor	72-43-5	0/72	nd	nd	µg/kg dw	0.6 U – 48,000 U	48,000 U	na	310,000	no	bsl
Toxaphene	8001-35-2	0/72	nd	nd	µg/kg dw	97 UJ – 480,000 U	480,000 U	na	1,600	yes	asl
VOCs											
1,1,1,2-Tetrachloroethane	630-20-6	0/54	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	9,800	no	bsl
1,1,1-Trichloroethane	71-55-6	1/69	170	170	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	15,000	no	bsl
1,1,2,2-Tetrachloroethane	79-34-5	0/67	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	2,900	no	bsl
1,1,2-Trichloroethane	79-00-5	2/69	1.5 J	41	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	190	no	ife
1,1,2-Trichlorotrifluoroethane	76-13-1	0/69	nd	nd	µg/kg dw	1.8 U – 2,200 U	2,200 U	na	1.8 x 10 ⁸	no	bsl
1,1-Dichloroethane	75-34-3	3/69	1.1	680	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	190	yes	asl
1,1-Dichloroethene	75-35-4	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	4,300	no	bsl
1,1-Dichloropropene	563-58-6	0/54	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
1,2,3-Trichlorobenzene	87-61-6	0/52	nd	nd	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	na	no	ntx
1,2,3-Trichloropropane	96-18-4	0/52	nd	nd	µg/kg dw	1.8 U – 2,200 U	2,200 U	na	410	no	ife
1,2,4-Trimethylbenzene	95-63-6	24/54	1.9 J	40,000	µg/kg dw	0.9 U – 7.1 UJ	40,000	na	5,500	yes	asl
1,2-Dibromo-3-chloropropane	96-12-8	0/69	nd	nd	µg/kg dw	3 UJ – 5,600 U	5,600 U	na	73	no	ife
1,2-Dibromoethane (EDB)	106-93-4	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	0.44	yes	asl
1,2-Dichloroethane	107-06-2	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	7.4	no	ife
1,2-Dichloroethene (total)	540-59-0	0/15	nd	nd	µg/kg dw	2.2 U – 4.7 U	4.7 U	na	50,000	no	bsl
1,2-Dichloropropane	78-87-5	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	4700	no	bsl
1,3,5-Trimethylbenzene	108-67-8	18/54	1.5	12,000	µg/kg dw	0.9 U – 120 U	12,000	na	1200	yes	asl
1,3-Dichloropropane	142-28-9	0/54	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	20,000,000	no	bsl
2,2-Dichloropropane	594-20-7	0/54	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
2-Chlorotoluene	95-49-8	0/52	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	20000000	no	bsl
2-Hexanone	591-78-6	0/69	nd	nd	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	na	no	ntx
4-Chlorotoluene	106-43-4	0/52	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	72,000,000	no	bsl
Acetone	67-64-1	49/69	11	1,800	µg/kg dw	5.6 U – 5,600 U	5,600 U	na	6.1 x 10 ⁸	no	bsl
Benzene	71-43-2	25/69	1.1	6,400	µg/kg dw	0.9 U – 810 U	6,400	na	52	yes	asl
Bromobenzene	108-86-1	0/52	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	41,000	no	bsl
Bromochloromethane	74-97-5	0/54	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
Bromodichloromethane	75-27-4	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	23	no	ife
Bromoform	75-25-2	0/67	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	1,600	no	bsl
Bromomethane	74-83-9	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	39	no	ife
Carbon disulfide	75-15-0	23/69	1.4	460	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	3,000,000	no	bsl
Carbon tetrachloride	56-23-5	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	70	no	ife

Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Chlorobenzene	108-90-7	7/69	1.2 JN	320	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	2,600	no	bsl
Chloroethane	75-00-3	1/69	2.9	2.9	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	370	no	ife
Chloroform	67-66-3	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	18	no	ife
Chloromethane	74-87-3	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	150	no	ife
cis-1,2-Dichloroethene	156-59-2	4/69	1.6 J	130,000	µg/kg dw	0.9 U – 1,100 U	130,000	na	400	yes	asl
cis-1,3-Dichloropropene	10061-01-5	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	8,400	no	bsl
Cyclohexane	110-82-7	3/15	1.3 J	31.6 J	µg/kg dw	2.2 U – 4.3 UJ	31.6 J	na	30,000,000	no	bsl
p-Cymene	99-87-6	17/54	1.3	11,000 J	µg/kg dw	0.9 U – 83 U	11,000 J	na	na	no	ntx
Dibromochloromethane	124-48-1	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	3,400	no	bsl
Dibromomethane	74-95-3	0/54	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	10,000,000	no	bsl
Dichlorodifluoromethane	75-71-8	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	78,000	no	bsl
Dichloromethane	75-09-2	18/69	2.0	370	µg/kg dw	1.9 U – 2,200 U	2,200 U	na	230	yes	asl
Ethylbenzene	100-41-4	19/69	2.0 J	26,000	µg/kg dw	0.9 U – 120 U	26,000	na	860	yes	asl
Isopropylbenzene	98-82-8	19/67	1.3	2,300	µg/kg dw	0.9 U – 120 U	2,300	na	2,400,000	no	bsl
Methyl acetate	79-20-9	0/15	nd	nd	µg/kg dw	11.1 UJ – 23.3 UJ	23.3 UJ	na	1.0 x 10 ⁹	no	bsl
Methyl ethyl ketone	78-93-3	36/69	7.6	240	µg/kg dw	4.9 U – 5,600 U	5,600 U	na	na	no	ntx
Methyl isobutyl ketone	108-10-1	3/69	5.2 J	18	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	na	no	ntx
Methylcyclohexane	108-87-2	5/15	3.7	185 J	µg/kg dw	2.2 U – 4.3 UJ	185 J	na	na	no	ntx
n-Butylbenzene	104-51-8	19/54	1.4 J	12,000	µg/kg dw	0.9 U – 83 U	12,000	na	na	no	ntx
n-Propylbenzene	103-65-1	19/53	1.3	6,700	µg/kg dw	0.9 U – 120 U	6,700	na	230,000	no	bsl
sec-Butylbenzene	135-98-8	11/52	1.2	2,000	µg/kg dw	0.9 U – 1,100 U	2,000	na	16,000	no	bsl
Styrene	100-42-5	1/69	1.9	1.9	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	5,000,000	no	bsl
tert-Butyl methyl ether	1634-04-4	3/69	2.2	6.9	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	500	no	ife
tert-Butylbenzene	98-06-6	0/52	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	na	no	ntx
Tetrachloroethene	127-18-4	5/69	1.9	10.8 J	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	2,700	no	bsl
Toluene	108-88-3	32/69	1.2	49,000	µg/kg dw	0.9 U – 810 U	49,000	na	2,400,000	no	bsl
trans-1,2-Dichloroethene	156-60-5	1/54	5,500	5,500	µg/kg dw	0.9 U – 1,100 U	5,500	na	1,000	yes	asl
trans-1,3-Dichloropropene	10061-02-6	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	8,400	no	bsl
Trichloroethene	79-01-6	6/69	1.5	2,400	µg/kg dw	0.9 U – 1,100 U	2,400	na	9.9	yes	asl
Trichlorofluoromethane	75-69-4	0/69	nd	nd	µg/kg dw	0.9 U – 1,100 U	1,100 U	na	29,000	no	bsl
Vinyl acetate	108-05-4	0/53	nd	nd	µg/kg dw	4.4 U – 5,600 U	5,600 U	na	4,200,000	no	bsl
Vinyl chloride	75-01-4	1/69	1,200	1,200	µg/kg dw	0.9 U – 1,100 U	1,200	na	10	yes	asl
o-Xylene	95-47-6	26/69	1.6	33,000	µg/kg dw	0.9 U – 83 U	33,000	na	10,000	no	sum
m,p-Xylene	108383/ 106423	27/69	1.5	120,000 J	µg/kg dw	0.9 U – 83 U	120,000 J	na	10,000	no	sum

Table 3: Occurrence and selection of COPCs for Facility Soil in the Future Outdoor Worker RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Worker Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Total xylenes	1330-20-7	29/69	1.8 J	150,000 J	µg/kg dw	0.9 U – 83 U	150,000 J	na	10,000	yes	asl
Petroleum^d											
TPH - Gasoline range	na	28/56	5.3	3,800	mg/kg dw	5.6 U – 57 U	3,800	na	110	no	asl
TPH - Diesel range	na	67/68	6.3	13,000	mg/kg dw	29 U – 29 U	13,000	na	23,000	no	bsl
TPH - Motor oil range	na	68/68	37	12,000	mg/kg dw	na	12,000	na	40,000	no	bsl

^a Background values are from DEQ (2002).

^b The worker soil RSL is the lowest of EPA industrial screening levels (2009d) and DEQ human health occupational, construction worker, or excavation worker RBCs for the following four exposure routes: soil ingestion, dermal absorption, and inhalation; volatilization to outdoor air; vapor intrusion into buildings; and leaching to groundwater (2007). For TPHs, the screening level is the lowest occupational DEQ RBC (2003).

^c Potassium was analyzed only in historical data, but not in samples collected in the RI/FS sampling effort because potassium is an essential nutrient and is not expected to be toxic to humans based on the daily reference intake for potassium of 4.7 g/day (Institute of Medicine 2004).

^d Aromatic and aliphatic TPHs were assumed to be equal to 15% and 85% of the TPH total for each of the three fractions (gasoline, diesel, and motor oil) based on ATSDR (1999). For the purposes of this HHRA, only aliphatic TPHs were carried forward as COPCs when above screening levels because the components of the aromatic TPHs (e.g., various PAHs and VOCs) were already assessed and thus the assessment of aromatic TPHs as an additional chemical group would double count risks.

asl – above screening level (selected as COPC)

BHC – benzene hexachloride

bsl – below screening level

COPC – contaminant of potential concern

CAS – Chemical Abstracts Service

cPAH – carcinogenic PAH

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

DL – detection limit

dw – dry weight

EDB – 1,2-Dibromoethane

HCID – hydrocarbon identification

hic – analyzed only in historical data

HPAH – high-molecular-weight

ife – infrequent exceedance of RSL by RLs (not selected as COPC)

J – estimated concentration

LPAH – low-molecular-weight PAH

na – not available

ND – not detected

ntx – no toxicity information (not selected as COPC)

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RBC – risk-based concentration

RSL – regional screening level

sum – chemical included in sum and is not evaluated separately

SVOC – semivolatile organic compound

teq – chemical included in TEQ calculation and is not evaluated separately

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

U – not detected at given concentration

VOC – volatile organic compound

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
Metals											
Aluminum (total)	7429-90-5	µg/L	2/2	621	5,890	na	5,890	na	na	no	ntx
Antimony (dissolved)	7440-36-0	µg/L	0/4	nd	nd	0.2 U	0.2	na	na	no	ntx
Antimony (total)	7440-36-0	µg/L	0/6	nd	nd	0.2 U - 1.6 U	1.6	na	na	no	ntx
Arsenic (dissolved)	7440-38-2	µg/L	4/4	3	19.4	na	19.4	na	na	no	ntx
Arsenic (total)	7440-38-2	µg/L	6/6	3.7	19.3	na	19.3	na	na	yes	cac
Barium (dissolved)	7440-39-3	µg/L	4/4	103	122	na	122	na	na	no	ntx
Barium (total)	7440-39-3	µg/L	6/6	116	365	na	365	na	na	no	ntx
Beryllium (total)	7440-41-7	µg/L	1/2	1.5	1.5	1 U	1.5	na	na	no	ntx
Cadmium (dissolved)	7440-43-9	µg/L	0/4	nd	nd	0.2 U	0.2	na	na	no	ntx
Cadmium (total)	7440-43-9	µg/L	2/6	0.4	0.869	0.2 U	0.869	na	na	no	ntx
Calcium (total)	7440-70-2	µg/L	2/2	80,200	89,900	na	89,900	na	na	no	ntx
Chromium (dissolved)	7440-47-3	µg/L	0/4	nd	nd	5 UJ	5	na	na	no	ntx
Chromium (total)	7440-47-3	µg/L	3/6	6 J	8	5 UJ	8	na	na	no	ntx
Cobalt (dissolved)	7440-48-4	µg/L	0/4	nd	nd	3 U	3	na	na	no	ntx
Cobalt (total)	7440-48-4	µg/L	2/6	3	12	3 U - 5 U	12	na	na	no	ntx
Copper (dissolved)	7440-50-8	µg/L	0/4	nd	nd	2 U	2	na	na	no	ntx
Copper (total)	7440-50-8	µg/L	3/6	6	11	2 U - 4 U	11	na	na	no	ntx
Iron (dissolved)	7439-89-6	µg/L	4/4	15,500	21,600	na	21,600	na	na	no	ntx
Iron (total)	7439-89-6	µg/L	6/6	19,600	28,800	na	28,800	na	na	no	ntx
Lead (dissolved)	7439-92-1	µg/L	0/4	nd	nd	1 U	1	na	na	no	ntx
Lead (total)	7439-92-1	µg/L	4/6	2	8.51	1 U	8.51	na	na	no	ntx
Magnesium (total)	7439-95-4	µg/L	2/2	24,900	27,100	na	27,100	na	na	no	ntx
Manganese (dissolved)	7439-96-5	µg/L	4/4	2,110	3,210	na	3,210	na	na	no	ntx
Manganese (total)	7439-96-5	µg/L	6/6	2,050	3,350	na	3,350	na	na	no	ntx
Mercury (dissolved)	7439-97-6	µg/L	0/4	nd	nd	0.1 U	0.1	yes	0.68	no	bsl
Mercury (total)	7439-97-6	µg/L	1/6	0.14	0.14	0.1 U	0.14	yes	0.68	no	bsl
Nickel (dissolved)	7440-02-0	µg/L	0/4	nd	nd	10 U - 10 UJ	10	na	na	no	ntx
Nickel (total)	7440-02-0	µg/L	2/6	10	20	10 U	20	na	na	no	ntx
Potassium (total)	2023695	µg/L	2/2	17,700	23,700	na	23,700	na	na	no	ntx
Selenium (dissolved)	7782-49-2	µg/L	2/4	0.5	0.7	0.5 U	0.7	na	na	no	ntx
Selenium (total)	7782-49-2	µg/L	1/6	0.5	0.5	0.5 U - 2 U	2	na	na	no	ntx
Silver (total)	7440-22-4	µg/L	0/2	nd	nd	1 U	1	na	na	no	ntx
Sodium (total)	7440-23-5	µg/L	2/2	15,600	21,100	na	21,100	na	na	no	ntx

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
Thallium (total)	7440-28-0	µg/L	2/2	0.0272	0.0301	na	0.0301	na	na	no	ntx
Vanadium (dissolved)	7440-62-2	µg/L	0/4	nd	nd	3 U	3	na	na	no	ntx
Vanadium (total)	7440-62-2	µg/L	4/6	4.3	54.4	3 U	54.4	na	na	no	ntx
Zinc (dissolved)	7440-66-6	µg/L	0/4	nd	nd	10 U	10	na	na	no	ntx
Zinc (total)	7440-66-6	µg/L	4/6	10	208	10 U	208	na	na	no	ntx
PAHs											
2-Chloronaphthalene	91-58-7	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	yes	icp	no	icp
2-Methylnaphthalene	91-57-6	µg/L	1/6	0.1 J	0.1 J	0.10 U - 0.37 U	0.37	yes	3,300	no	bsl
Acenaphthene	83-32-9	µg/L	3/6	2.5	3.2	0.10 U - 0.4 U	3.2	yes	icp	no	icp
Acenaphthylene	208-96-8	µg/L	0/6	nd	nd	0.10 U - 0.4 U	0.4	yes	icp	no	icp
Anthracene	120-12-7	µg/L	2/6	0.15	0.18	0.10 U - 0.4 U	0.4	no	na	no	ntx
Benzo(a)anthracene	56-55-3	µg/L	0/6	nd	nd	0.10 U - 0.4 U	0.4	no	na	no	teq
Benzo(a)pyrene	50-32-8	µg/L	0/6	nd	nd	0.10 U - 0.8 U	0.8	no	na	no	teq
Benzo(b)fluoranthene	205-99-2	µg/L	0/6	nd	nd	0.10 U - 0.8 U	0.8	yes	icp	no	teq
Benzo(g,h,i)perylene	191-24-2	µg/L	0/6	nd	nd	0.10 U - 2 U	2	na	na	no	ntx
Benzo(k)fluoranthene	207-08-9	µg/L	0/6	nd	nd	0.10 U - 0.4 U	0.4	no	na	no	teq
Total benzofluoranthenes	56832-73-6	µg/L	0/6	nd	nd	0.10 U - 0.8 U	0.8	na	na	no	ntx
Chrysene	218-01-9	µg/L	0/6	nd	nd	0.10 U - 0.4 U	0.4	yes	icp	no	teq
Dibenzo(a,h)anthracene	53-70-3	µg/L	0/6	nd	nd	0.10 U - 4 U	4	no	na	no	teq
Dibenzofuran	132-64-9	µg/L	0/6	nd	nd	0.10 U - 0.4 U	0.4	yes	icp	no	icp
Fluoranthene	206-44-0	µg/L	3/6	0.12	0.64	0.10 U - 0.4 U	0.64	no	na	no	ntx
Fluorene	86-73-7	µg/L	3/6	0.29	1.9	0.10 U - 0.4 U	1.9	yes	icp	no	icp
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	0/6	nd	nd	0.10 U - 4 U	4	no	na	no	teq
Naphthalene	91-20-3	µg/L	0/6	nd	nd	0.10 U - 0.4 U	0.4	yes	150	no	bsl
Phenanthrene	85-01-8	µg/L	0/6	nd	nd	0.10 U - 0.4 U	0.4	na	na	no	ntx
Pyrene	129-00-0	µg/L	2/6	0.12	0.53	0.10 U - 0.4 U	0.53	yes	icp	no	icp
Total HPAHs	na	µg/L	3/6	0.12	1.17	0.10 U - 4 U	4	na	na	no	ntx
Total LPAHs	na	µg/L	3/6	3.1	5.1	0.10 U - 0.4 U	5.1	na	na	no	ntx
cPAH TEQ	na	µg/L	0/6	nd	nd	0.0910 U - 1.50 U	1.5	no	na	no	ntx
Total PAHs	na	µg/L	3/6	3.3	6.3	0.10 U - 4 U	6.3	na	na	no	ntx
Phthalates											
Bis(2-ethylhexyl)phthalate	117-81-7	µg/L	2/2	0.62	1.6	na	1.6	no	na	no	ntx
Butyl benzyl phthalate	85-68-7	µg/L	0/2	nd	nd	1.8 U - 2 U	2	no	na	no	ntx
Diethyl phthalate	84-66-2	µg/L	1/2	0.25 J	0.25 J	0.4 U	0.4	no	na	no	ntx
Dimethyl phthalate	131-11-3	µg/L	0/2	nd	nd	0.74 U - 0.8 U	0.8	no	na	no	ntx

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
Di-n-butyl phthalate	84-74-2	µg/L	1/2	0.15 J	0.15 J	0.4 U	0.4	no	na	no	ntx
Di-n-octyl phthalate	117-84-0	µg/L	0/2	nd	nd	1.8 U - 2 U	2	no	na	no	ntx
Other SVOCs											
1,2,4-Trichlorobenzene	120-82-1	µg/L	0/6	nd	nd	1 U - 5.0 U	5	yes	3,400	no	bsl
1,2-Dichlorobenzene	95-50-1	µg/L	1/6	0.22 J	0.22 J	1.0 U	1	yes	2,600	no	bsl
1,3-Dichlorobenzene	541-73-1	µg/L	2/6	0.2 J	0.35 J	1.0 U	1	yes	830	no	bsl
1,4-Dichlorobenzene	106-46-7	µg/L	2/6	1	1.4	1.0 U	1.4	yes	8,200	no	bsl
2,4,5-Trichlorophenol	95-95-4	µg/L	0/2	nd	nd	1.8 U - 2 U	2	no	na	no	ntx
2,4,6-Trichlorophenol	88-06-2	µg/L	0/2	nd	nd	0.74 U - 0.8 U	0.8	no	na	no	ntx
2,4-Dichlorophenol	120-83-2	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
2,4-Dimethylphenol	105-67-9	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
2,4-Dinitrophenol	51-28-5	µg/L	0/2	nd	nd	7.4 U - 8 U	8	no	na	no	ntx
2,4-Dinitrotoluene	121-14-2	µg/L	0/2	nd	nd	0.74 U - 0.8 U	0.8	no	na	no	ntx
2,6-Dinitrotoluene	606-20-2	µg/L	0/2	nd	nd	3.7 U - 4 U	4	no	na	no	ntx
2-Chlorophenol	95-57-8	µg/L	1/2	0.97	0.97	0.37 U	0.97	yes	1,100	no	bsl
2-Methylphenol	95-48-7	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
2-Nitroaniline	88-74-4	µg/L	0/2	nd	nd	0.74 U - 0.8 U	0.8	na	na	no	ntx
2-Nitrophenol	88-75-5	µg/L	0/2	nd	nd	1.8 U - 2 U	2	no	na	no	ntx
3,3'-Dichlorobenzidine	91-94-1	µg/L	0/2	nd	nd	1.8 U - 2 U	2	no	na	no	ntx
3-Nitroaniline	99-09-2	µg/L	0/2	nd	nd	1.8 U - 2 U	2	na	na	no	ntx
4,6-Dinitro-o-cresol	534-52-1	µg/L	0/2	nd	nd	3.7 U - 4 U	4	no	na	no	ntx
4-Bromophenyl phenyl ether	101-55-3	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	na	na	no	ntx
4-Chloro-3-methylphenol	59-50-7	µg/L	0/2	nd	nd	1.8 U - 2 U	2	na	na	no	ntx
4-Chloroaniline	106-47-8	µg/L	0/2	nd	nd	0.74 U - 0.8 U	0.8	na	na	no	ntx
4-Chlorophenyl phenyl ether	7005-72-3	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	na	na	no	ntx
4-Methylphenol	106-44-5	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
4-Nitroaniline	100-01-6	µg/L	0/2	nd	nd	1.8 U - 2 U	2	na	na	no	ntx
4-Nitrophenol	100-02-7	µg/L	0/2	nd	nd	3.7 U - 4 U	4	no	na	no	ntx
Acetophenone	98-86-2	µg/L	1/2	0.16 J	0.16 J	0.37 U	0.37	yes	8.0 x 10 ⁵	no	bsl
Atrazine	1912-24-9	µg/L	0/2	nd	nd	1.8 U - 2 U	2	na	na	no	ntx
Benzaldehyde	100-52-7	µg/L	0/2	nd	nd	0.37 UJ - 0.4 UJ	0.4	yes	3.6 x 10 ⁵	no	bsl
Biphenyl	92-52-4	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	yes	icp	no	icp
bis(2-chloroethoxy)methane	111-91-1	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	na	na	no	ntx
bis(2-chloroethyl)ether	111-44-4	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	yes	10	no	bsl
bis(2-chloroisopropyl)ether	108-60-1	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	yes	51	no	bsl

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
Caprolactam	105-60-2	µg/L	0/2	nd	nd	1.8 U - 2 U	2	na	na	no	ntx
Carbazole	86-74-8	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
Hexachlorobenzene (dissolved)	118-74-1	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	1.0	no	bsl
Hexachlorobenzene	118-74-1	µg/L	0/6	nd	nd	0.0050 U - 0.4 U	0.4	yes	1.0	no	bsl
Hexachlorobutadiene (dissolved)	87-68-3	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	0.33	no	bsl
Hexachlorobutadiene	87-68-3	µg/L	0/6	nd	nd	0.0050 U - 0.4 U	0.4	yes	0.33	yes	asl
Hexachlorocyclopentadiene	77-47-4	µg/L	0/2	nd	nd	1.8 U - 2 U	2	yes	50	no	bsl
Hexachloroethane	67-72-1	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	yes	3.8	no	bsl
Isophorone	78-59-1	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
Nitrobenzene	98-95-3	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	yes	2,000	no	bsl
n-Nitroso-di-n-propylamine	621-64-7	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
n-Nitrosodiphenylamine	86-30-6	µg/L	0/2	nd	nd	0.37 U - 0.4 U	0.4	no	na	no	ntx
Pentachlorophenol	87-86-5	µg/L	0/2	nd	nd	1.8 U - 2 U	2	no	na	no	ntx
Phenol	108-95-2	µg/L	2/2	0.23 J	0.37 J	na	0.37	no	na	no	ntx
PCBs											
Aroclor-1016	12674-11-2	µg/L	0/6	nd	nd	0.10 U - 0.46 UJ	0.46	na	na	no	sum
Aroclor-1221	11104-28-2	µg/L	0/6	nd	nd	0.10 U - 0.92 UJ	0.92	na	na	no	sum
Aroclor-1232	11141-16-5	µg/L	0/6	nd	nd	0.10 U - 0.46 UJ	0.46	na	na	no	sum
Aroclor-1242	53469-21-9	µg/L	0/6	nd	nd	0.10 U - 0.46 UJ	0.46	na	na	no	sum
Aroclor-1248	12672-29-6	µg/L	0/6	nd	nd	0.10 U - 0.46 UJ	0.46	na	na	no	sum
Aroclor-1254	11097-69-1	µg/L	0/6	nd	nd	0.10 U - 0.46 UJ	0.46	na	na	no	sum
Aroclor-1260	11096-82-5	µg/L	0/6	nd	nd	0.10 U - 0.46 UJ	0.46	na	na	no	sum
Total PCBs	1336-36-3	µg/L	0/6	nd	nd	0.10 U - 0.92 UJ	0.92	na	na	no	ntx
Pesticides											
2,4'-DDD (dissolved)	53-19-0	µg/L	0/1	nd	nd	0.010 U	0.01	no	na	no	sum
2,4'-DDD	53-19-0	µg/L	2/4	0.0093 J	0.012	0.010 U	0.012	no	na	no	sum
2,4'-DDE (dissolved)	3424-82-6	µg/L	0/1	nd	nd	0.010 U	0.01	yes	29	no	sum
2,4'-DDE	3424-82-6	µg/L	0/4	nd	nd	0.010 U	0.01	yes	29	no	sum
2,4'-DDT (dissolved)	789-02-6	µg/L	0/1	nd	nd	0.010 U	0.01	no	na	no	sum
2,4'-DDT	789-02-6	µg/L	0/4	nd	nd	0.010 U	0.01	no	na	no	sum
4,4'-DDD (dissolved)	72-54-8	µg/L	1/1	0.011	0.011	na	0.011	no	na	no	sum
4,4'-DDD	72-54-8	µg/L	3/6	0.029	0.24 J	0.010 U - 0.018 U	0.24	no	na	no	sum
4,4'-DDE (dissolved)	72-55-9	µg/L	0/1	nd	nd	0.010 U	0.01	yes	29	no	sum
4,4'-DDE	72-55-9	µg/L	0/6	nd	nd	0.010 U - 0.018 UJ	0.018	yes	29	no	sum
4,4'-DDT (dissolved)	50-29-3	µg/L	0/1	nd	nd	0.010 U	0.01	no	na	no	sum

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
4,4'-DDT	50-29-3	µg/L	0/6	nd	nd	0.010 U - 0.018 U	0.018	no	na	no	sum
Total DDTs (dissolved)	na	µg/L	1/1	0.011	0.011	na	0.011	yes	29	no	bsl
Total DDTs	na	µg/L	3/6	0.038 J	0.24 J	0.010 U - 0.018 U	0.24	yes	29	no	bsl
Aldrin (dissolved)	309-00-2	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	0.071	no	bsl
Aldrin	309-00-2	µg/L	0/6	nd	nd	0.0050 U - 0.018 U	0.018	yes	0.071	no	bsl
Dieldrin (dissolved)	60-57-1	µg/L	0/1	nd	nd	0.010 U	0.01	yes	0.86	no	bsl
Dieldrin	60-57-1	µg/L	0/6	nd	nd	0.010 U - 0.018 UJ	0.018	yes	0.86	no	bsl
Total aldrin/dieldrin (dissolved)	na	µg/L	0/1	nd	nd	0.010 U	0.01	na	na	no	ntx
Total aldrin/dieldrin	na	µg/L	0/6	nd	nd	0.010 U - 0.018 U	0.018	na	na	no	ntx
alpha-BHC (dissolved)	319-84-6	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	3.1	no	bsl
alpha-BHC	319-84-6	µg/L	0/6	nd	nd	0.0050 U - 0.018 U	0.018	yes	3.1	no	bsl
beta-BHC (dissolved)	319-85-7	µg/L	0/1	nd	nd	0.0050 U	0.005	no	na	no	ntx
beta-BHC	319-85-7	µg/L	0/6	nd	nd	0.0050 U - 0.018 UJ	0.018	no	na	no	ntx
gamma-BHC (dissolved)	58-89-9	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	11	no	bsl
gamma-BHC	58-89-9	µg/L	0/6	nd	nd	0.0050 U - 0.018 U	0.018	yes	11	no	bsl
delta-BHC (dissolved)	319-86-8	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	3.1	no	bsl
delta-BHC	319-86-8	µg/L	0/6	nd	nd	0.0050 U - 0.018 UJ	0.018	yes	3.1	no	bsl
alpha-Chlordane (dissolved)	5103-71-9	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	12	no	bsl
alpha-Chlordane	5103-71-9	µg/L	0/6	nd	nd	0.0050 U - 0.018 UJ	0.018	yes	12	no	bsl
gamma-Chlordane (dissolved)	5103-74-2	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	12	no	bsl
gamma-Chlordane	5103-74-2	µg/L	0/6	nd	nd	0.0050 U - 0.018 U	0.018	yes	12	no	bsl
Total chlordane (dissolved)	57-74-9	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	12	no	bsl
Total chlordane	57-74-9	µg/L	0/6	nd	nd	0.0050 U - 0.018 U	0.018	yes	12	no	bsl
alpha-Endosulfan (dissolved)	959-98-8	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	icp	no	icp
alpha-Endosulfan	959-98-8	µg/L	0/6	nd	nd	0.0050 U - 0.018 UJ	0.018	yes	icp	no	icp
beta-Endosulfan (dissolved)	33213-65-9	µg/L	0/1	nd	nd	0.010 U	0.01	yes	icp	no	icp
beta-Endosulfan	33213-65-9	µg/L	0/6	nd	nd	0.010 U - 0.018 U	0.018	yes	icp	no	icp
Endosulfan sulfate (dissolved)	1031-07-8	µg/L	0/1	nd	nd	0.010 U	0.01	yes	icp	no	icp
Endosulfan sulfate	1031-07-8	µg/L	0/6	nd	nd	0.010 U - 0.018 UJ	0.018	yes	icp	no	icp
Endrin (dissolved)	72-20-8	µg/L	0/1	nd	nd	0.010 U	0.01	no	na	no	ntx
Endrin	72-20-8	µg/L	0/6	nd	nd	0.010 U - 0.018 U	0.018	no	na	no	ntx
Endrin aldehyde (dissolved)	7421-93-4	µg/L	0/1	nd	nd	0.010 U	0.01	no	na	no	ntx
Endrin aldehyde	7421-93-4	µg/L	0/6	nd	nd	0.010 U - 0.018 U	0.018	no	na	no	ntx
Endrin ketone (dissolved)	53494-70-5	µg/L	0/1	nd	nd	0.010 U	0.01	no	na	no	ntx
Endrin ketone	53494-70-5	µg/L	0/6	nd	nd	0.010 U - 0.018 UJ	0.018	no	na	no	ntx

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
Heptachlor (dissolved)	76-44-8	µg/L	0/1	nd	nd	0.0050 U	0.005	yes	0.4	no	bsl
Heptachlor	76-44-8	µg/L	0/6	nd	nd	0.0050 U - 0.018 UJ	0.018	yes	0.4	no	bsl
Heptachlor epoxide (dissolved)	1024-57-3	µg/L	0/1	nd	nd	0.0050 U	0.005	no	na	no	ntx
Heptachlor epoxide	1024-57-3	µg/L	0/6	nd	nd	0.0050 U - 0.018 UJ	0.018	no	na	no	ntx
Methoxychlor (dissolved)	72-43-5	µg/L	0/1	nd	nd	0.050 U	0.05	yes	icp	no	icp
Methoxychlor	72-43-5	µg/L	0/6	nd	nd	0.018 U - 0.050 U	0.05	yes	icp	no	icp
Toxaphene (dissolved)	8001-35-2	µg/L	0/1	nd	nd	0.50 U	0.5	no	na	no	ntx
Toxaphene	8001-35-2	µg/L	0/6	nd	nd	0.50 U - 4.6 UJ	4.6	no	na	no	ntx
VOCs											
1,1,1,2-Tetrachloroethane	630-20-6	µg/L	0/4	nd	nd	1.0 U	1	yes	3.3	no	bsl
1,1,1-Trichloroethane	71-55-6	µg/L	0/6	nd	nd	1.0 U	1	yes	3,100	no	bsl
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	0/6	nd	nd	1.0 U	1	yes	3.0	no	bsl
1,1,2-Trichloroethane	79-00-5	µg/L	0/6	nd	nd	1 U	1	yes	5.0	no	bsl
1,1,2-Trichlorotrifluoroethane	76-13-1	µg/L	0/6	nd	nd	1 U - 2.0 U	2	yes	1,500	no	bsl
1,1-Dichloroethane	75-34-3	µg/L	0/6	nd	nd	1.0 U	1	yes	2,200	no	bsl
1,1-Dichloroethene	75-35-4	µg/L	0/6	nd	nd	1.0 U - 1 U	1	yes	190	no	bsl
1,1-Dichloropropene	563-58-6	µg/L	0/4	nd	nd	1.0 U	1	yes	0.84	yes	asl
1,2,3-Trichlorobenzene	87-61-6	µg/L	0/4	nd	nd	5.0 U	5	yes	24	no	bsl
1,2,3-Trichloropropane	96-18-4	µg/L	0/4	nd	nd	2.0 U	2	yes	290	no	bsl
1,2,4-Trimethylbenzene	95-63-6	µg/L	0/4	nd	nd	1.0 U	1	yes	24	no	bsl
1,2-Dibromo-3-chloropropane	96-12-8	µg/L	0/6	nd	nd	1 U - 5.0 U	5	yes	33	no	bsl
1,2-Dibromoethane (EDB)	106-93-4	µg/L	0/6	nd	nd	1.0 U	1	yes	0.36	yes	asl
1,2-Dichloroethane	107-06-2	µg/L	0/6	nd	nd	1 U - 1.0 U	1	yes	5.0	no	bsl
1,2-Dichloroethene (total)	na	µg/L	0/2	nd	nd	1 U	1	yes	190	no	bsl
1,2-Dichloropropane	78-87-5	µg/L	0/6	nd	nd	1.0 U	1	yes	35	no	bsl
1,3,5-Trimethylbenzene	108-67-8	µg/L	0/4	nd	nd	1.0 U	1	yes	25	no	bsl
1,3-Dichloropropane	142-28-9	µg/L	0/4	nd	nd	1.0 U - 5.0 U	5	yes	35	no	bsl
2,2-Dichloropropane	594-20-7	µg/L	0/4	nd	nd	1.0 U	1	yes	35	no	bsl
2-Chlorotoluene	95-49-8	µg/L	0/4	nd	nd	1.0 U	1	na	na	no	ntx
2-Hexanone	591-78-6	µg/L	0/6	nd	nd	2 U - 5.0 U	5	na	na	no	ntx
4-Chlorotoluene	106-43-4	µg/L	0/4	nd	nd	1.0 U	1	na	na	no	ntx
Acetone	67-64-1	µg/L	2/6	5.7	8.3	2 U - 10 U	10	yes	2.2 x 10 ⁵	no	bsl
Benzene	71-43-2	µg/L	2/6	2.3	2.9	1.0 U - 6.2 U	6.2	yes	5.0	yes	cac
Bromobenzene	108-86-1	µg/L	0/4	nd	nd	1.0 U	1	na	na	no	ntx
Bromochloromethane	74-97-5	µg/L	0/4	nd	nd	1.0 U	1	na	na	no	ntx

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
Bromodichloromethane	75-27-4	µg/L	0/6	nd	nd	1.0 U	1	yes	2.1	no	bsl
Bromoform	75-25-2	µg/L	0/6	nd	nd	1 U - 1.0 U	1	yes	0.0083	yes	asl
Bromomethane	74-83-9	µg/L	0/6	nd	nd	1 U	1	na	na	no	ntx
Carbon disulfide	75-15-0	µg/L	0/6	nd	nd	1.0 U - 2 U	2	yes	560	no	bsl
Carbon tetrachloride	56-23-5	µg/L	0/6	nd	nd	1 U - 1.0 U	1	yes	5.0	no	bsl
Chlorobenzene	108-90-7	µg/L	6/6	4.1	130	na	130	yes	390	no	bsl
Chloroethane	75-00-3	µg/L	0/6	nd	nd	1.0 U - 2 U	2	yes	28,000	no	bsl
Chloroform	67-66-3	µg/L	0/6	nd	nd	1.0 U	1	yes	80	no	bsl
Chloromethane	74-87-3	µg/L	0/6	nd	nd	1 U	1	yes	6.7	no	bsl
cis-1,2-Dichloroethene	156-59-2	µg/L	1/6	0.23 J	0.23 J	1 U - 1.0 U	1	yes	210	no	bsl
cis-1,3-Dichloropropene	10061-01-5	µg/L	0/6	nd	nd	1 U	1	yes	0.84	yes	asl
Cyclohexane	110-82-7	µg/L	0/2	nd	nd	1 U	1	na	na	no	ntx
p-Cymene	99-87-6	µg/L	0/4	nd	nd	1.0 U	1	na	na	no	ntx
Dibromochloromethane	124-48-1	µg/L	0/6	nd	nd	1 U - 1.0 U	1	yes	3.2	no	bsl
Dibromomethane	74-95-3	µg/L	0/4	nd	nd	1.0 U	1	yes	990	no	bsl
Dichlorodifluoromethane	75-71-8	µg/L	0/6	nd	nd	1.0 U - 1 U	1	yes	14	no	bsl
Dichloromethane	75-09-2	µg/L	0/6	nd	nd	1 U - 2.0 U	2	yes	58	no	bsl
Ethylbenzene	100-41-4	µg/L	0/6	nd	nd	1.0 U	1	yes	700	no	bsl
Isopropylbenzene	98-82-8	µg/L	1/6	0.039 J	0.039 J	1.0 U	1	yes	8.4	no	bsl
Methyl acetate	79-20-9	µg/L	0/2	nd	nd	1 U	1	yes	7.2 x 10 ⁵	no	bsl
Methyl ethyl ketone	78-93-3	µg/L	0/6	nd	nd	2 U - 5.0 U	5	yes	4.4 x 10 ⁵	no	bsl
Methyl isobutyl ketone	108-10-1	µg/L	0/6	nd	nd	2 U - 5.0 U	5	yes	14,000	no	bsl
Methylcyclohexane	108-87-2	µg/L	0/2	nd	nd	1 U	1	yes	710	no	bsl
n-Butylbenzene	104-51-8	µg/L	0/4	nd	nd	1.0 U	1	yes	260	no	bsl
n-Propylbenzene	103-65-1	µg/L	0/4	nd	nd	1.0 U	1	yes	320	no	bsl
sec-Butylbenzene	135-98-8	µg/L	0/4	nd	nd	1.0 U	1	yes	250	no	bsl
Styrene	100-42-5	µg/L	1/6	0.24 J	0.24 J	1.0 U	1	yes	8,900	no	bsl
tert-Butyl methyl ether	1634-04-4	µg/L	0/6	nd	nd	1.0 U - 1 U	1	yes	1.2 x 10 ⁵	no	bsl
tert-Butylbenzene	98-06-6	µg/L	0/4	nd	nd	1.0 U	1	yes	290	no	bsl
Tetrachloroethene	127-18-4	µg/L	0/6	nd	nd	1.0 U	1	yes	5.0	no	bsl
Toluene	108-88-3	µg/L	0/6	nd	nd	1.0 U	1	yes	1,500	no	bsl
trans-1,2-Dichloroethene	156-60-5	µg/L	0/4	nd	nd	1.0 U	1	yes	180	no	bsl
trans-1,3-Dichloropropene	10061-02-6	µg/L	0/6	nd	nd	0.94 U - 1.0 U	1	yes	0.84	yes	asl
Trichloroethene	79-01-6	µg/L	0/6	nd	nd	1.0 U	1	yes	5.0	no	bsl
Trichlorofluoromethane	75-69-4	µg/L	0/6	nd	nd	1 U - 1.0 U	1	yes	180	no	bsl

Table 4. Occurrence and selection of COPCs for Industrial/Commercial Worker Vapor Intrusion Scenario

Chemical	CAS Number	Unit	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Range of NDs	Value Used for Screening	Toxic and Volatile? ^a	EPA Vapor Intrusion SL ^a	COPC Flag?	Rationale for Selection or Exclusion
Vinyl acetate	108-05-4	µg/L	0/4	nd	nd	5.0 U - 5.0 UJ	5	yes	9,600	no	bsl
Vinyl chloride	75-01-4	µg/L	1/6	0.22 J	0.22 J	1.0 U	1	yes	2.0	yes	cac
o-Xylene	95-47-6	µg/L	0/6	nd	nd	1.0 U	1	yes	33,000	no	bsl
m,p-Xylene	108383/106423	µg/L	0/6	nd	nd	1.0 U - 2.0 U	2	yes	22,000	no	bsl
Total xylenes	1330-20-7	µg/L	0/6	nd	nd	1 U - 2.0 U	2	na	na	no	ntx
Petroleum											
TPH - Gasoline range	na	mg/L	1/4	0.27	0.27	0.25 U	0.27	na	na	no	ntx
TPH - Diesel range	na	mg/L	0/4	nd	nd	0.25 U	0.25	na	na	no	ntx
TPH - Motor oil range	na	mg/L	0/4	nd	nd	0.50 U	0.5	na	na	no	ntx

^a The EPA vapor intrusion screening level for groundwater is from EPA's Draft Vapor Intrusion guidance (2005). This guidance also includes information regarding whether a given chemical is sufficiently toxic and volatile for inclusion in this analysis.

^b Potassium was analyzed only in historical data, but not in samples collected in the RI/FS sampling effort because potassium is an essential nutrient and is not expected to be toxic to humans based on the daily reference intake for potassium of 4.7 g/day (Institute of Medicine 2004).

asl – above screening level (selected as COPC)

BHC – benzene hexachloride

bsl – below screening level

COPC – contaminant of potential concern

CAS – Chemical Abstracts Service

cac – Class A carcinogen (selected as COPC)

cPAH – carcinogenic PAH

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

DL – detection limit

dw – dry weight

EDB – 1,2-dibromoethane

HCID – hydrocarbon identification

HPAH – high-molecular-weight PAH

icp – incomplete pathway

J – estimated concentration

LPAH – low-molecular-weight PAH

MCL – maximum contaminant level

MCLG – maximum contaminant level goal

na – not available

ND – not detected

ntx – no toxicity information (not selected as COPC)

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RBC – risk-based concentration

RSL – regional screening level

sum – chemical included in sum and is not evaluated separately

SVOC – semivolatile organic compound

teq – chemical included in TEQ calculation and is not evaluated separately

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

U – not detected at given concentration

VOC – volatile organic compound

Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Metals											
Aluminum	7429-90-5	5/5	5,990	12,100	mg/kg dw	na	12,100	na	7,700	yes	asl
Antimony	7440-36-0	7/61	0.7 J	8.4 J	mg/kg dw	0.2 UJ – 4.5 U	8.4 J	4	3.1	yes	asl
Arsenic	7440-38-2	61/61	1.5	53.1	mg/kg dw	na	53.1	7	0.39	yes	asl
Barium	7440-39-3	61/61	64.5	481	mg/kg dw	na	481	na	1,500	no	bsl
Beryllium	7440-41-7	5/5	0.36	0.544	mg/kg dw	na	0.544	na	15	no	bsl
Cadmium	7440-43-9	54/61	0.2	4	mg/kg dw	0.2 U – 0.4 U	4	1	7	no	bsl
Calcium	7440-70-2	5/5	3,960	18,500	mg/kg dw	na	18,500	na	na	no	ntx
Chromium	7440-47-3	61/61	6.6	149	mg/kg dw	na	149	42	32	yes	asl
Cobalt	7440-48-4	61/61	3.5	34.3	mg/kg dw	na	34.3	na	2.3	yes	asl
Copper	7440-50-8	61/61	10.3	1,240 J	mg/kg dw	na	1,240 J	36	290	yes	asl
Iron	7439-89-6	5/5	17,400	56,500	mg/kg dw	na	56,500	na	5,500	yes	asl
Lead	7439-92-1	61/61	6 J	320	mg/kg dw	na	320	17	30	yes	asl
Magnesium	7439-95-4	5/5	2,800	4,700	mg/kg dw	na	4,700	na	na	no	ntx
Manganese	7439-96-5	5/5	417	1,090	mg/kg dw	na	1,090	na	180	yes	asl
Mercury	7439-97-6	54/61	0.04 J	0.4	mg/kg dw	0.05 U – 0.26 U	0.4	0.07	2.3	no	bsl
Nickel	7440-02-0	61/61	10	48	mg/kg dw	na	48	38	150	no	bsl
Potassium	7440-09-7	5/5	993	2,440	mg/kg dw	na	2,440	na	5.5	no	his ^c
Selenium	7782-49-2	2/61	0.55	1.1	mg/kg dw	0.1 U – 3 U	3 U	2	39	no	bsl
Silver	7440-22-4	5/5	0.55	1.5	mg/kg dw	na	1.5	na	39	no	bsl
Sodium	7440-23-5	5/5	311	850	mg/kg dw	na	850	na	na	no	ntx
Thallium	7440-28-0	0/5	nd	nd	mg/kg dw	0.3 U – 0.75 U	0.75 U	na	0.51	yes	asl
Vanadium	7440-62-2	61/61	16.1	148	mg/kg dw	na	148	na	39	yes	asl
Zinc	7440-66-6	61/61	37	748	mg/kg dw	na	748	86	2300	no	bsl
PAHs											
2-Chloronaphthalene	91-58-7	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	6,300,000	no	bsl
2-Methylnaphthalene	91-57-6	55/61	5.0	2,880	µg/kg dw	5.0 U – 277 U	2,880	na	31,000	no	bsl
Acenaphthene	83-32-9	11/61	5.4	700	µg/kg dw	4.6 U – 883 U	883 U	na	290,000	no	bsl
Acenaphthylene	208-96-8	22/61	4.8	836 J	µg/kg dw	4.6 U – 782 U	836 J	na	340,000	no	bsl
Anthracene	120-12-7	54/61	4.9	2,300	µg/kg dw	5.0 U – 735 U	2,300	na	1,700,000	no	bsl
Benzo(a)anthracene	56-55-3	55/61	6.9	5,700	µg/kg dw	72 U – 883 U	5,700	na	150	yes	teq
Benzo(a)pyrene	50-32-8	58/61	9.9	4,000	µg/kg dw	195 U – 782 U	4,000	na	15	yes	teq
Benzo(b)fluoranthene	205-99-2	57/61	15	2,900	µg/kg dw	389 U – 1,560 U	2,900	na	150	yes	teq
Benzo(g,h,i)perylene	191-24-2	57/61	8.8	6,000	µg/kg dw	72 U – 3,910 U	6,000	na	na	no	ntx

Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Benzo(k)fluoranthene	207-08-9	56/61	6.4	3,500	µg/kg dw	195 U – 883 U	3,500	na	1,500	yes	teq
Total benzofluoranthenes	56832-73-6	57/61	21	6,400	µg/kg dw	389 U – 1,560 U	6,400	na	na	no	ntx
Chrysene	218-01-9	58/61	11	6,100	µg/kg dw	195 U – 735 U	6,100	na	15,000	no	teq
Dibenzo(a,h)anthracene	53-70-3	17/61	5.0 J	1,200	µg/kg dw	4.6 U – 8,830 U	8,830 U	na	15	yes	teq
Dibenzofuran	132-64-9	35/61	4.8	781 J	µg/kg dw	4.8 U – 782 U	782 U	na	na	no	ntx
Fluoranthene	206-44-0	60/61	16	17,000	µg/kg dw	277 U – 277 U	17,000	na	230,000	no	bsl
Fluorene	86-73-7	17/61	5.4	417 J	µg/kg dw	4.6 U – 735 U	735 U	na	230,000	no	bsl
Indeno(1,2,3-cd)pyrene	193-39-5	56/61	8.9	3,830 J	µg/kg dw	72 U – 7,820 U	7,820 U	na	150	yes	teq
Naphthalene	91-20-3	55/61	5.0	4,210	µg/kg dw	5.0 U – 277 U	4,210	na	72	yes	asl
Phenanthrene	85-01-8	60/61	7.9	8,800	µg/kg dw	277 U – 277 U	8,800	na	na	no	ntx
Pyrene	129-00-0	60/61	18	16,000	µg/kg dw	277 U – 277 U	16,000	na	170,000	no	bsl
Total HPAHs	na	60/61	105	57,000	µg/kg dw	2,770 U – 2,770 U	57,000	na	na	no	ntx
Total LPAHs	na	60/61	7.9	12,200	µg/kg dw	277 U – 277 U	12,200	na	na	no	ntx
cPAH TEQ	na	59/61	14.7	5,200	µg/kg dw	625 U – 888 U	5,200	na	15	yes	asl
Total PAHs	na	60/61	113	69,000	µg/kg dw	2,770 U – 2,770 U	69,000	na	na	no	ntx
Phthalates											
Bis(2-ethylhexyl)phthalate	117-81-7	13/15	22	9,100	µg/kg dw	195 U – 277 U	9,100	na	35,000	no	bsl
Butyl benzyl phthalate	85-68-7	1/15	3,140 J	3,140 J	µg/kg dw	20 U – 3,910 U	3,910 U	na	260,000	no	bsl
Diethyl phthalate	84-66-2	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	4,900,000	no	bsl
Dimethyl phthalate	131-11-3	0/15	nd	nd	µg/kg dw	20 U – 1,770 U	1,770 U	na	na	no	ntx
Di-n-butyl phthalate	84-74-2	3/15	59	2,400	µg/kg dw	20 U – 883 U	2,400	na	610,000	no	bsl
Di-n-octyl phthalate	117-84-0	0/15	nd	nd	µg/kg dw	20 U – 4,420 U	4,420 U	na	na	no	ntx
Other SVOCs											
1,2,4-Trichlorobenzene	120-82-1	0/52	nd	nd	µg/kg dw	3 UJ – 39 U	39 U	na	8,700	no	bsl
1,2-Dichlorobenzene	95-50-1	0/52	nd	nd	µg/kg dw	0.9 U – 15 UJ	15 UJ	na	940	no	bsl
1,3-Dichlorobenzene	541-73-1	0/52	nd	nd	µg/kg dw	0.9 U – 15 UJ	15 UJ	na	280	no	bsl
1,4-Dichlorobenzene	106-46-7	2/52	2.3 J	19 J	µg/kg dw	0.9 U – 15 UJ	19 J	na	91	no	bsl
2,4,5-Trichlorophenol	95-95-4	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	610,000	no	bsl
2,4,6-Trichlorophenol	88-06-2	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	1,900	no	ife
2,4-Dichlorophenol	120-83-2	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	18,000	no	bsl
2,4-Dimethylphenol	105-67-9	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	120,000	no	bsl
2,4-Dinitrophenol	51-28-5	0/14	nd	nd	µg/kg dw	200 U – 17,700 U	17,700 U	na	12,000	yes	asl
2,4-Dinitrotoluene	121-14-2	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	1,600	yes	asl
2,6-Dinitrotoluene	606-20-2	0/15	nd	nd	µg/kg dw	98 U – 8,830 U	8,830 U	na	420	yes	asl
2-Chlorophenol	95-57-8	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	39,000	no	bsl

Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
2-Methylphenol	95-48-7	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	310,000	no	bsl
2-Nitroaniline	88-74-4	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	18,000	no	bsl
2-Nitrophenol	88-75-5	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	na	no	ntx
3,3'-Dichlorobenzidine	91-94-1	0/14	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	28	yes	asl
3-Nitroaniline	99-09-2	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	na	no	ntx
4,6-Dinitro-o-cresol	534-52-1	0/14	nd	nd	µg/kg dw	200 U – 10,000 U	10,000 U	na	610	yes	asl
4-Bromophenyl phenyl ether	101-55-3	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	na	no	ntx
4-Chloro-3-methylphenol	59-50-7	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	na	no	ntx
4-Chloroaniline	106-47-8	0/14	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	2,400	no	ife
4-Chlorophenyl phenyl ether	7005-72-3	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	na	no	ntx
4-Methylphenol	106-44-5	4/15	25	190	µg/kg dw	20 U – 1,000 U	1,000 U	na	31,000	no	bsl
4-Nitroaniline	100-01-6	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	24,000	no	bsl
4-Nitrophenol	100-02-7	0/15	nd	nd	µg/kg dw	98 U – 8,830 U	8,830 U	na	na	no	ntx
Acetophenone	98-86-2	1/5	630 J	630 J	µg/kg dw	195 U – 782 U	782 U	na	7,800,000	no	bsl
Aniline	62-53-3	0/9	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	85,000	no	bsl
Atrazine	1912-24-9	0/5	nd	nd	µg/kg dw	973 U – 4,420 U	4,420 U	na	2,100	yes	asl
Benzaldehyde	100-52-7	5/5	59.6 J	1,080 J	µg/kg dw	na	1,080 J	na	7,800,000	no	bsl
Benzoic acid	65-85-0	8/10	250	28,000	µg/kg dw	590 U – 880 U	28,000	na	240,000,000	no	bsl
Benzyl alcohol	100-51-6	5/10	15 J	2,100	µg/kg dw	20 U – 99 U	2,100	na	3,100,000	no	bsl
Biphenyl	92-52-4	1/5	836 J	836 J	µg/kg dw	195 U – 782 U	836 J	na	3,900,000	no	bsl
bis(2-chloroethoxy)methane	111-91-1	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	18,000	no	bsl
bis(2-chloroethyl)ether	111-44-4	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	190	yes	asl
bis(2-chloroisopropyl)ether	108-60-1	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	3,500	no	bsl
Caprolactam	105-60-2	0/5	nd	nd	µg/kg dw	973 U – 4,420 U	4,420 U	na	3,100,000	no	bsl
Carbazole	86-74-8	4/15	12 J	66 J	µg/kg dw	20 U – 1,000 U	1,000 U	na	na	no	ntx
Hexachlorobenzene	118-74-1	1/61	42	42	µg/kg dw	0.96 U – 883 U	883 U	na	300	no	ife
Hexachlorobutadiene	87-68-3	0/61	nd	nd	µg/kg dw	0.96 U – 883 U	883 U	na	6,200	no	bsl
Hexachlorocyclopentadiene	77-47-4	0/14	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	37,000	no	bsl
Hexachloroethane	67-72-1	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	2,200	no	bsl
Isophorone	78-59-1	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	510,000	no	bsl
Nitrobenzene	98-95-3	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	4,400	no	bsl
n-Nitroso-di-n-propylamine	621-64-7	0/15	nd	nd	µg/kg dw	98 U – 5,200 U	5,200 U	na	69	yes	asl
n-Nitrosodiphenylamine	86-30-6	0/15	nd	nd	µg/kg dw	20 U – 1,000 U	1,000 U	na	99,000	no	bsl
Pentachlorophenol	87-86-5	1/15	80 J	80 J	µg/kg dw	98 U – 5,200 U	5,200 U	na	480	yes	asl
Phenol	108-95-2	5/15	53	498 J	µg/kg dw	20 U – 1,000 U	1,000 U	na	1,800,000	no	bsl

Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
PCBs											
Aroclor-1016	12674-11-2	0/61	nd	nd	µg/kg dw	23 U – 1,300 U	1,300 U	na	390	no	sum
Aroclor-1221	11104-28-2	0/61	nd	nd	µg/kg dw	32 U – 1,300 U	1,300 U	na	170	no	sum
Aroclor-1232	11141-16-5	0/61	nd	nd	µg/kg dw	23 U – 1,300 U	1,300 U	na	170	no	sum
Aroclor-1242	53469-21-9	0/61	nd	nd	µg/kg dw	23 U – 1,300 U	1,300 U	na	220	no	sum
Aroclor-1248	12672-29-6	2/61	120	390	µg/kg dw	23 U – 1,300 U	1,300 U	na	220	no	sum
Aroclor-1254	11097-69-1	4/61	170	2,200	µg/kg dw	23 U – 1,300 U	2,200	na	220	no	sum
Aroclor-1260	11096-82-5	39/61	35	2,300	µg/kg dw	24 U – 160 U	2,300	na	220	no	sum
Total PCBs	1336-36-3	40/61	35	4,200	µg/kg dw	32 U – 990 U	4,200	na	220	yes	asl
Pesticides											
2,4'-DDD	53-19-0	38/56	4.2	7,700	µg/kg dw	1.9 U – 78 U	7,700	na	na	no	sum
2,4'-DDE	3424-82-6	4/56	4.5 J	370	µg/kg dw	1.9 U – 980 U	980 U	na	na	no	sum
2,4'-DDT	789-02-6	24/56	6.6	11,000	µg/kg dw	1.9 U – 160 U	11,000	na	na	no	sum
4,4'-DDD	72-54-8	56/61	2.4 J	27,000	µg/kg dw	2.5 U – 130 U	27,000	na	2,000	no	sum
4,4'-DDE	72-55-9	44/61	3.8	2,700	µg/kg dw	2.4 U – 980 U	2,700	na	1,400	no	sum
4,4'-DDT	50-29-3	45/61	2.6	27,000	µg/kg dw	0.97 U – 160 U	27,000	na	1,700	no	sum
Total DDTs	na	60/61	2.7 J	46,000	µg/kg dw	130 U – 130 U	46,000	na	1,700	yes	asl
Aldrin	309-00-2	0/61	nd	nd	µg/kg dw	0.92 U – 490 U	490 U	na	29	yes	asl
Dieldrin	60-57-1	0/61	nd	nd	µg/kg dw	0.97 U – 980 U	980 U	na	23	yes	asl
Total aldrin/dieldrin	na	0/61	nd	nd	µg/kg dw	0.97 U – 980 U	980 U	na	na	no	ntx
alpha-BHC	319-84-6	0/61	nd	nd	µg/kg dw	0.92 U – 490 U	490 U	na	4.8	yes	asl
beta-BHC	319-85-7	0/61	nd	nd	µg/kg dw	0.92 U – 490 U	490 U	na	270	no	ife
gamma-BHC	58-89-9	0/61	nd	nd	µg/kg dw	0.92 U – 490 U	490 U	na	14	yes	asl
delta-BHC	319-86-8	2/61	3.0	3.0	µg/kg dw	0.92 U – 490 U	490 U	na	1,600	no	bsl
alpha-Chlordane	5103-71-9	0/61	nd	nd	µg/kg dw	0.96 U – 490 U	490 U	na	1,600	no	bsl
gamma-Chlordane	5103-74-2	0/61	nd	nd	µg/kg dw	0.96 U – 490 U	490 U	na	1,600	no	bsl
Total chlordane	57-74-9	0/61	nd	nd	µg/kg dw	0.96 U – 490 U	490 U	na	1,600	no	bsl
alpha-Endosulfan	959-98-8	0/61	nd	nd	µg/kg dw	0.92 U – 490 U	490 U	na	37,000	no	bsl
beta-Endosulfan	33213-65-9	0/61	nd	nd	µg/kg dw	0.92 U – 980 U	980 U	na	37,000	no	bsl
Endosulfan sulfate	1031-07-8	0/61	nd	nd	µg/kg dw	1.9 U – 980 U	980 U	na	37,000	no	bsl
Endrin	72-20-8	0/61	nd	nd	µg/kg dw	0.92 U – 980 U	980 U	na	1,800	no	bsl
Endrin aldehyde	7421-93-4	0/61	nd	nd	µg/kg dw	0.97 U – 980 U	980 U	na	1,800	no	bsl
Endrin ketone	53494-70-5	0/61	nd	nd	µg/kg dw	0.97 U – 980 U	980 U	na	1,800	no	bsl
Heptachlor	76-44-8	0/61	nd	nd	µg/kg dw	0.92 U – 490 U	490 U	na	110	no	ife
Heptachlor epoxide	1024-57-3	0/61	nd	nd	µg/kg dw	0.92 U – 490 U	490 U	na	53	no	ife

Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Methoxychlor	72-43-5	1/61	4.6 J	4.6 J	µg/kg dw	0.92 U – 4,900 U	4,900 U	na	31,000	no	bsl
Toxaphene	8001-35-2	0/61	nd	nd	µg/kg dw	96 U – 49,000 U	49,000 U	na	440	yes	asl
VOCs											
1,1,1,2-Tetrachloroethane	630-20-6	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 U	7.7 U	na	2,000	no	bsl
1,1,1-Trichloroethane	71-55-6	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	3,700	no	bsl
1,1,2,2-Tetrachloroethane	79-34-5	0/52	nd	nd	µg/kg dw	0.9 U – 15 UJ	15 UJ	na	590	no	bsl
1,1,2-Trichloroethane	79-00-5	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	48	no	bsl
1,1,2-Trichlorotrifluoroethane	76-13-1	0/52	nd	nd	µg/kg dw	1.8 U – 15 U	15 U	na	43,000,000	no	bsl
1,1-Dichloroethane	75-34-3	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	32	no	bsl
1,1-Dichloroethene	75-35-4	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	1,100	no	bsl
1,1-Dichloropropene	563-58-6	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 U	7.7 U	na	na	no	ntx
1,2,3-Trichlorobenzene	87-61-6	0/47	nd	nd	µg/kg dw	4.4 U – 39 UJ	39 UJ	na	na	no	ntx
1,2,3-Trichloropropane	96-18-4	0/47	nd	nd	µg/kg dw	1.8 U – 15 UJ	15 UJ	na	91	no	bsl
1,2,4-Trimethylbenzene	95-63-6	3/47	3.6 J	9.2	µg/kg dw	0.9 U – 7.7 UJ	9.2	na	1,400	no	bsl
1,2-Dibromo-3-chloropropane	96-12-8	0/52	nd	nd	µg/kg dw	3 UJ – 150 UJ	150 UJ	na	5.6	yes	asl
1,2-Dibromoethane (EDB)	106-93-4	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	0.073	yes	asl
1,2-Dichloroethane	107-06-2	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	1.2	yes	asl
1,2-Dichloroethene (total)	540-59-0	0/5	nd	nd	µg/kg dw	3 U – 15 U	15 U	na	11,000	no	bsl
1,2-Dichloropropane	78-87-5	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	930	no	bsl
1,3,5-Trimethylbenzene	108-67-8	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	310	no	bsl
1,3-Dichloropropane	142-28-9	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 U	7.7 U	na	160,000	no	bsl
2,2-Dichloropropane	594-20-7	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 U	7.7 U	na	na	no	ntx
2-Chlorotoluene	95-49-8	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	1,600,000	no	bsl
2-Hexanone	591-78-6	0/52	nd	nd	µg/kg dw	4.4 U – 59.8 UJ	59.8 UJ	na	na	no	ntx
4-Chlorotoluene	106-43-4	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	5,500,000	no	bsl
Acetone	67-64-1	47/52	12	2,300	µg/kg dw	61.1 UJ – 299 UJ	2,300	na	6,100,000	no	bsl
Benzene	71-43-2	24/52	1.4	56	µg/kg dw	0.9 U – 15 U	56	na	8.4	yes	asl
Bromobenzene	108-86-1	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	9,400	no	bsl
Bromochloromethane	74-97-5	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 U	7.7 U	na	na	no	ntx
Bromodichloromethane	75-27-4	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	3.9	yes	asl
Bromoform	75-25-2	0/52	nd	nd	µg/kg dw	0.9 U – 15 UJ	15 UJ	na	220	no	bsl
Bromomethane	74-83-9	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	9.6	no	ife
Carbon disulfide	75-15-0	3/52	3.9	7.5	µg/kg dw	0.9 U – 59.8 U	59.8 U	na	670,000	no	bsl
Carbon tetrachloride	56-23-5	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	11	no	ife
Chlorobenzene	108-90-7	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	640	no	bsl

Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Chloroethane	75-00-3	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	61	no	bsl
Chloroform	67-66-3	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	3.1	yes	asl
Chloromethane	74-87-3	0/52	nd	nd	µg/kg dw	0.9 U – 29.9 U	29.9 U	na	27	no	ife
cis-1,2-Dichloroethene	156-59-2	3/52	1.9	9.7	µg/kg dw	0.9 U – 15 U	15 U	na	100	no	bsl
cis-1,3-Dichloropropene	10061-01-5	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	1,700	no	bsl
Cyclohexane	110-82-7	0/5	nd	nd	µg/kg dw	3 UJ – 15 U	15 U	na	7,200,000	no	bsl
p-Cymene	99-87-6	3/47	3.4 J	72 J	µg/kg dw	0.9 U – 7.7 UJ	72 J	na	na	no	ntx
Dibromochloromethane	124-48-1	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	700	no	bsl
Dibromomethane	74-95-3	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 U	7.7 U	na	78,000	no	bsl
Dichlorodifluoromethane	75-71-8	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	19,000	no	bsl
Dichloromethane	75-09-2	5/52	2.1	5.3	µg/kg dw	1.9 U – 58.7 U	58.7 U	na	35	no	ife
Ethylbenzene	100-41-4	1/52	3.0	3.0	µg/kg dw	0.9 U – 15 U	15 U	na	140	no	bsl
Isopropylbenzene	98-82-8	0/52	nd	nd	µg/kg dw	0.9 U – 15 UJ	15 UJ	na	230,000	no	bsl
Methyl acetate	79-20-9	0/5	nd	nd	µg/kg dw	15.3 U – 74.8 U	74.8 U	na	78,000,000	no	bsl
Methyl ethyl ketone	78-93-3	45/52	7.6	260	µg/kg dw	4.9 U – 150 UJ	260	na	na	no	ntx
Methyl isobutyl ketone	108-10-1	1/52	15	15	µg/kg dw	4.4 U – 59.8 UJ	59.8 UJ	na	na	no	ntx
Methylcyclohexane	108-87-2	0/5	nd	nd	µg/kg dw	3 UJ – 15 U	15 U	na	na	no	ntx
n-Butylbenzene	104-51-8	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	na	no	ntx
n-Propylbenzene	103-65-1	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	5,200	no	bsl
sec-Butylbenzene	135-98-8	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	4,000	no	bsl
Styrene	100-42-5	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	39,000	no	bsl
tert-Butyl methyl ether	1634-04-4	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	82	no	bsl
tert-Butylbenzene	98-06-6	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 UJ	7.7 UJ	na	na	no	ntx
Tetrachloroethene	127-18-4	2/52	5.1	30	µg/kg dw	0.9 U – 15 U	30	na	570	no	bsl
Toluene	108-88-3	36/52	1.4	68	µg/kg dw	0.9 U – 15 U	68	na	14,000	no	bsl
trans-1,2-Dichloroethene	156-60-5	0/47	nd	nd	µg/kg dw	0.9 U – 7.7 U	7.7 U	na	250	no	bsl
trans-1,3-Dichloropropene	10061-02-6	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	1,700	no	bsl
Trichloroethene	79-01-6	2/52	2.4	4.7	µg/kg dw	0.9 U – 15 U	15 U	na	1.7	yes	asl
Trichlorofluoromethane	75-69-4	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	7,200	no	bsl
Vinyl acetate	108-05-4	0/47	nd	nd	µg/kg dw	4.4 U – 39 U	39 U	na	99,000	no	bsl
Vinyl chloride	75-01-4	0/52	nd	nd	µg/kg dw	0.9 U – 15 U	15 U	na	0.5	yes	asl
o-Xylene	95-47-6	1/52	5.2	5.2	µg/kg dw	0.9 U – 15 U	15 U	na	2,500	no	sum
m,p-Xylene	108383/ 106423	5/52	2.0 J	6.3	µg/kg dw	0.9 U – 29.9 U	29.9 U	na	2,500	no	sum
Total xylenes	1330-20-7	5/52	2.0 J	11.5	µg/kg dw	0.9 U – 29.9 U	29.9 U	na	2,500	no	bsl

Table 5: Occurrence and selection of COPCs for Wetland Soil in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Petroleum^d											
TPH - Gasoline range	na	4/56	5.3	20	mg/kg dw	6.1 U – 58 U	58 U	na	26	yes	asl
TPH - Diesel range	na	54/60	6.3	4,000	mg/kg dw	7.4 U – 29 U	4,000	na	2,800	yes	asl
TPH - Motor oil range	na	57/60	28	6,600	mg/kg dw	15 U – 17 U	6,600	na	9,800	no	bsl

^a Background values are from DEQ (2002).

^b The residential/recreational soil RSL is the lowest of EPA residential screening levels (2009d) and DEQ RBCs through soil ingestion, dermal contact, and inhalation; residential exposure through volatilization to outdoor air and vapor intrusion into buildings; and residential exposure through leaching to groundwater (2007). For TPHs, the screening level is the lowest occupational DEQ RBC (2003).

^c Potassium was analyzed only in historical data, but not in samples collected in the RI/FS sampling effort because potassium is an essential nutrient and is not expected to be toxic to humans based on the daily reference intake for potassium of 4.7 g/day (Institute of Medicine 2004).

^d Aromatic and aliphatic TPHs were assumed to be equal to 15% and 85% of the TPH total for each of the three fractions (gasoline, diesel, and motor oil) based on ATSDR (1999). For the purposes of this HHRA, only aliphatic TPHs were carried forward as COPCs when above screening levels because the components of the aromatic TPHs (e.g., various PAHs and VOCs) were already assessed and thus the assessment of aromatic TPHs as an additional chemical group would double count risks.

asl – above screening level (selected as COPC)

BHC – benzene hexachloride

bsl – below screening level

COPC – contaminant of potential concern

CAS – Chemical Abstracts Service

cPAH – carcinogenic PAH

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

DL – detection limit

dw – dry weight

EDB – 1,2-dibromoethane

HCID – hydrocarbon identification

HPAH – high-molecular-weight PAH

ife – infrequent exceedance of RSL by RLs (not selected as COPC)

J – estimated concentration

LPAH – low-molecular-weight PAH

na – not available

ND – not detected

ntx – no toxicity information (not selected as COPC)

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RBC – risk-based concentration

RSL – regional screening level

sum – chemical included in sum and is not evaluated separately

SVOC – semivolatile organic compound

teq – chemical included in TEQ calculation and is not evaluated separately

TEQ – toxic equivalent

U – not detected at given concentration

VOC – volatile organic compound

Table 6: Occurrence and selection of COPCs for Lake Sediment in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Metals											
Antimony	7440-36-0	0/11	nd	nd	mg/kg dw	0.3 UJ – 1 UJ	1 UJ	4	3.1	no	bsl
Arsenic	7440-38-2	11/11	2.6	7	mg/kg dw	na	7	7	0.39	yes	asl
Barium	7440-39-3	11/11	128	220	mg/kg dw	na	220	na	1,500	no	bsl
Cadmium	7440-43-9	8/11	2	2	mg/kg dw	0.3 U – 0.7 U	2	1	7	no	bsl
Chromium	7440-47-3	11/11	7.7	34	mg/kg dw	na	34	42	32	yes	asl
Cobalt	7440-48-4	11/11	7.3	15	mg/kg dw	na	15	na	2.3	yes	asl
Copper	7440-50-8	11/11	16.2	72	mg/kg dw	na	72	36	290	no	bsl
Lead	7439-92-1	11/11	9	56	mg/kg dw	na	56	17	30	yes	asl
Mercury	7439-97-6	1/11	0.2 J	0.2 J	mg/kg dw	0.06 U – 0.3 U	0.3 U	0.07	2.3	no	bsl
Nickel	7440-02-0	11/11	11	31	mg/kg dw	na	31	38	150	no	bsl
Selenium	7782-49-2	0/11	nd	nd	mg/kg dw	0.7 U – 4 U	4 U	2	39	no	bsl
Vanadium	7440-62-2	11/11	32.7	74	mg/kg dw	na	74	na	39	yes	asl
Zinc	7440-66-6	11/11	80	229	mg/kg dw	na	229	86	2,300	no	bsl
PAHs											
2-Methylnaphthalene	91-57-6	7/11	7.9	31	µg/kg dw	5.0 U – 30 U	31	na	31,000	no	bsl
Acenaphthene	83-32-9	5/11	5.0	11 JN	µg/kg dw	5.0 U – 30 U	30 U	na	290,000	no	bsl
Acenaphthylene	208-96-8	3/11	5.0	7.0	µg/kg dw	5.0 U – 30 U	30 U	na	340,000	no	bsl
Anthracene	120-12-7	6/11	5.9	26	µg/kg dw	5.0 U – 30 U	30 U	na	1,700,000	no	bsl
Benzo(a)anthracene	56-55-3	11/11	6.9	74	µg/kg dw	na	74	na	150	no	teq
Benzo(a)pyrene	50-32-8	11/11	7.9	83	µg/kg dw	na	83	na	15	yes	teq
Benzo(b)fluoranthene	205-99-2	11/11	8.4	71	µg/kg dw	na	71	na	150	no	teq
Benzo(g,h,i)perylene	191-24-2	9/11	14	71	µg/kg dw	5.0 U – 5.0 U	71	na	na	no	ntx
Benzo(k)fluoranthene	207-08-9	11/11	8.4	71	µg/kg dw	na	71	na	1,500	no	teq
Total benzofluoranthenes	56832-73-6	11/11	16.8	142	µg/kg dw	na	142	na	na	no	ntx
Chrysene	218-01-9	11/11	9.4	110	µg/kg dw	na	110	na	15,000	no	teq
Dibenzo(a,h)anthracene	53-70-3	3/11	5.4	6.5	µg/kg dw	5.0 U – 30 U	30 U	na	15	yes	teq
Dibenzofuran	132-64-9	3/11	5.0	7.4	µg/kg dw	5.0 U – 30 U	30 U	na	na	no	ntx
Fluoranthene	206-44-0	11/11	20	190	µg/kg dw	na	190	na	230,000	no	bsl
Fluorene	86-73-7	6/11	5.9	26	µg/kg dw	5.0 U – 30 U	30 U	na	230,000	no	bsl
Indeno(1,2,3-cd)pyrene	193-39-5	9/11	11	59	µg/kg dw	5.0 U – 5.0 U	59	na	150	no	teq
Naphthalene	91-20-3	11/11	5.4	61	µg/kg dw	na	61	na	72	no	bsl
Phenanthrene	85-01-8	11/11	15	120	µg/kg dw	na	120	na	na	no	ntx
Pyrene	129-00-0	11/11	23	180	µg/kg dw	na	180	na	170,000	no	bsl
Total HPAHs	na	11/11	84	910	µg/kg dw	na	910	na	na	no	ntx

Table 6: Occurrence and selection of COPCs for Lake Sediment in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Total LPAHs	na	11/11	20	230	µg/kg dw	na	230	na	na	no	ntx
cPAH TEQ	na	11/11	11.6	118	µg/kg dw	na	118	na	15	yes	asl
Total PAHs	na	11/11	104	1,060	µg/kg dw	na	1,060	na	na	no	ntx
Other SVOCs											
1,2,4-Trichlorobenzene	120-82-1	0/11	nd	nd	µg/kg dw	5.3 U – 41 U	41 U	na	8,700	no	bsl
1,2-Dichlorobenzene	95-50-1	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	940	no	bsl
1,3-Dichlorobenzene	541-73-1	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	280	no	bsl
1,4-Dichlorobenzene	106-46-7	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	91	no	bsl
Hexachlorobenzene	118-74-1	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	300	no	bsl
Hexachlorobutadiene	87-68-3	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	6,200	no	bsl
PCBs											
Aroclor-1016	12674-11-2	0/11	nd	nd	µg/kg dw	32 U – 33 U	33 U	na	390	no	sum
Aroclor-1221	11104-28-2	0/11	nd	nd	µg/kg dw	32 U – 33 U	33 U	na	170	no	sum
Aroclor-1232	11141-16-5	0/11	nd	nd	µg/kg dw	32 U – 33 U	33 U	na	170	no	sum
Aroclor-1242	53469-21-9	0/11	nd	nd	µg/kg dw	32 U – 33 U	33 U	na	220	no	sum
Aroclor-1248	12672-29-6	0/11	nd	nd	µg/kg dw	32 U – 33 U	33 U	na	220	no	sum
Aroclor-1254	11097-69-1	7/11	58	71	µg/kg dw	32 U – 49 U	71	na	220	no	sum
Aroclor-1260	11096-82-5	7/11	35	60	µg/kg dw	32 U – 33 U	60	na	220	no	sum
Total PCBs	1336-36-3	7/11	93	131	µg/kg dw	32 U – 49 U	131	na	220	no	bsl
Pesticides											
2,4'-DDD	53-19-0	8/11	8.6 JN	61 JN	µg/kg dw	4.8 U – 25 U	61 JN	na	na	no	sum
2,4'-DDE	3424-82-6	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	na	no	sum
2,4'-DDT	789-02-6	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	na	no	sum
4,4'-DDD	72-54-8	11/11	11 J	47	µg/kg dw	na	47	na	2,000	no	sum
4,4'-DDE	72-55-9	11/11	9.1	150	µg/kg dw	na	150	na	1,400	no	sum
4,4'-DDT	50-29-3	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	1,700	no	sum
Total DDTs	na	11/11	22 J	250	µg/kg dw	na	250	na	1,700	no	bsl
Aldrin	309-00-2	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	29	no	bsl
Dieldrin	60-57-1	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	23	yes	asl
Total aldrin/dieldrin	na	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	na	no	ntx
alpha-BHC	319-84-6	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	4.8	yes	asl
beta-BHC	319-85-7	0/11	nd	nd	µg/kg dw	2.4 U – 23 U	23 U	na	270	no	bsl
gamma-BHC	58-89-9	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	14	no	bsl
delta-BHC	319-86-8	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	1,600	no	bsl
alpha-Chlordane	5103-71-9	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	1,600	no	bsl
gamma-Chlordane	5103-74-2	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	1,600	no	bsl

Table 6: Occurrence and selection of COPCs for Lake Sediment in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Total chlordane	57-74-9	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	1,600	no	bsl
alpha-Endosulfan	959-98-8	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	37,000	no	bsl
beta-Endosulfan	33213-65-9	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	37,000	no	bsl
Endosulfan sulfate	1031-07-8	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	37,000	no	bsl
Endrin	72-20-8	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	1,800	no	bsl
Endrin aldehyde	7421-93-4	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	1,800	no	bsl
Endrin ketone	53494-70-5	0/11	nd	nd	µg/kg dw	4.8 U – 25 U	25 U	na	1,800	no	bsl
Heptachlor	76-44-8	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	110	no	bsl
Heptachlor epoxide	1024-57-3	0/11	nd	nd	µg/kg dw	2.4 U – 12 U	12 U	na	53	no	bsl
Methoxychlor	72-43-5	0/11	nd	nd	µg/kg dw	24 U – 120 U	120 U	na	31,000	no	bsl
Toxaphene	8001-35-2	0/11	nd	nd	µg/kg dw	970 U – 5,000 U	5,000 U	na	440	yes	asl
VOCs											
1,1,1,2-Tetrachloroethane	630-20-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	2,000	no	bsl
1,1,1-Trichloroethane	71-55-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	3,700	no	bsl
1,1,2,2-Tetrachloroethane	79-34-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	590	no	bsl
1,1,2-Trichloroethane	79-00-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	48	no	bsl
1,1,2-Trichlorotrifluoroethane	76-13-1	0/11	nd	nd	µg/kg dw	2.1 U – 16 U	16 U	na	43,000,000	no	bsl
1,1-Dichloroethane	75-34-3	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	32	no	bsl
1,1-Dichloroethene	75-35-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	1,100	no	bsl
1,1-Dichloropropene	563-58-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	na	no	ntx
1,2,3-Trichlorobenzene	87-61-6	0/11	nd	nd	µg/kg dw	5.3 U – 41 U	41 U	na	na	no	ntx
1,2,3-Trichloropropane	96-18-4	0/11	nd	nd	µg/kg dw	2.1 U – 16 U	16 U	na	91	no	bsl
1,2,4-Trimethylbenzene	95-63-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	1,400	no	bsl
1,2-Dibromo-3-chloropropane	96-12-8	0/11	nd	nd	µg/kg dw	5.3 U – 41 U	41 U	na	5.6	yes	asl
1,2-Dibromoethane (EDB)	106-93-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	0.073	yes	asl
1,2-Dichloroethane	107-06-2	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	1.2	yes	asl
1,2-Dichloropropane	78-87-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	930	no	bsl
1,3,5-Trimethylbenzene	108-67-8	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	310	no	bsl
1,3-Dichloropropane	142-28-9	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	160,000	no	bsl
2,2-Dichloropropane	594-20-7	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	na	no	ntx
2-Chlorotoluene	95-49-8	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	1,600,000	no	bsl
2-Hexanone	591-78-6	0/11	nd	nd	µg/kg dw	5.3 U – 41 U	41 U	na	na	no	ntx
4-Chlorotoluene	106-43-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	5,500,000	no	bsl
Acetone	67-64-1	10/11	78 JN	1,100	µg/kg dw	35 U – 35 U	1,100	na	6,100,000	no	bsl
Benzene	71-43-2	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	8.4	yes	cac
Bromobenzene	108-86-1	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	9,400	no	bsl

Table 6: Occurrence and selection of COPCs for Lake Sediment in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
Bromochloromethane	74-97-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	na	no	ntx
Bromodichloromethane	75-27-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 UJ	na	3.9	yes	asl
Bromoform	75-25-2	0/10	nd	nd	µg/kg dw	1.1 U – 8.2 UJ	8.2 U	na	220	no	bsl
Bromomethane	74-83-9	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	9.6	no	bsl
Carbon disulfide	75-15-0	11/11	4.9	140	µg/kg dw	na	140	na	670,000	no	bsl
Carbon tetrachloride	56-23-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	11	no	bsl
Chlorobenzene	108-90-7	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	640	no	bsl
Chloroethane	75-00-3	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	61	no	bsl
Chloroform	67-66-3	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	3.1	yes	asl
Chloromethane	74-87-3	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	27	no	bsl
cis-1,2-Dichloroethene	156-59-2	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	100	no	bsl
cis-1,3-Dichloropropene	10061-01-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 UJ	8.2 UJ	na	1,700	no	bsl
p-Cymene	99-87-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	na	no	ntx
Dibromochloromethane	124-48-1	0/10	nd	nd	µg/kg dw	1.1 U – 8.2 UJ	8.2 U	na	700	no	bsl
Dibromomethane	74-95-3	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	78,000	no	bsl
Dichlorodifluoromethane	75-71-8	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	19,000	no	bsl
Dichloromethane	75-09-2	0/11	nd	nd	µg/kg dw	2.1 U – 16 U	16 U	na	35	no	bsl
Ethylbenzene	100-41-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	140	no	bsl
Isopropylbenzene	98-82-8	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	230,000	no	bsl
Methyl ethyl ketone	78-93-3	10/11	9.4	140	µg/kg dw	5.3 U – 5.3 U	140	na	na	no	ntx
Methyl isobutyl ketone	108-10-1	0/11	nd	nd	µg/kg dw	5.3 U – 41 U	41 U	na	na	no	ntx
n-Butylbenzene	104-51-8	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	na	no	ntx
n-Propylbenzene	103-65-1	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	5,200	no	bsl
sec-Butylbenzene	135-98-8	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	4,000	no	bsl
Styrene	100-42-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	39,000	no	bsl
tert-Butyl methyl ether	1634-04-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	82	no	bsl
tert-Butylbenzene	98-06-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	na	no	ntx
Tetrachloroethene	127-18-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	570	no	bsl
Toluene	108-88-3	3/11	1.2	17	µg/kg dw	6.0 U – 8.2 U	17	na	14,000	no	bsl
trans-1,2-Dichloroethene	156-60-5	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	250	no	bsl
trans-1,3-Dichloropropene	10061-02-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	1,700	no	bsl
Trichloroethene	79-01-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	1.7	yes	asl
Trichlorofluoromethane	75-69-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	7,200	no	bsl
Vinyl acetate	108-05-4	0/10	nd	nd	µg/kg dw	5.3 U – 43 U	43 U	na	99,000	no	bsl
Vinyl chloride	75-01-4	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	0.5	yes	asl
o-Xylene	95-47-6	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	2,500	no	sum

Table 6: Occurrence and selection of COPCs for Lake Sediment in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Background Conc. ^a	Residential Recreational Soil RSL ^b	COPC Flag?	Rationale for Selection or Exclusion
m,p-Xylene	108383/106423	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	2,500	no	sum
Total xylenes	1330-20-7	0/11	nd	nd	µg/kg dw	1.1 U – 8.2 U	8.2 U	na	2,500	no	bsl
Petroleum^c											
TPH - Gasoline range	na	1/11	31	31	mg/kg dw	7.7 U – 80 U	80 U	na	26	yes	asl
TPH - Diesel range	na	11/11	16	270	mg/kg dw	na	270	na	2,800	no	bsl
TPH - Motor oil range	na	11/11	130	2,000	mg/kg dw	na	2,000	na	9,800	no	bsl

^a Background values are from DEQ (2002).

^b The residential/recreational sediment RSL is the lowest of EPA residential screening levels (2009d) and DEQ RBCs through soil ingestion, dermal contact, and inhalation; residential exposure through volatilization to outdoor air and vapor intrusion into buildings; and residential exposure through leaching to groundwater (2007). Soil RSLs are used because no sediment-specific RSLs are available. For TPHs, the screening level is the lowest occupational DEQ RBC (2003).

^c Aromatic and aliphatic TPHs were assumed to be equal to 15% and 85% of the TPH total for each of the three fractions (gasoline, diesel, and motor oil) based on ATSDR (1999). For the purposes of this HHRA, only aliphatic TPHs were carried forward as COPCs when above screening levels because the components of the aromatic TPHs (e.g., various PAHs and VOCs) were already assessed and thus the assessment of aromatic TPHs as an additional chemical group would double count risks.

asl – above screening level (selected as COPC)

BHC – benzene hexachloride

bsl – below screening level

COPC – contaminant of potential concern

CAS – Chemical Abstracts Service

cac – Class A carcinogen (selected as COPC)

cPAH – carcinogenic PAH

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

DL – detection limit

dw – dry weight

EDB – 1,2-dibromoethane

HPAH – high-molecular-weight PAH

J – estimated concentration

LPAH – low-molecular-weight PAH

na – not available

ND – not detected

ntx – no toxicity information (not selected as COPC)

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RBC – risk-based concentration

RSL – regional screening level

sum – chemical included in sum and is not evaluated separately

SVOC – semivolatile organic compound

teq – chemical included in TEQ calculation and is not evaluated separately

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

U – not detected at given concentration

VOC – volatile organic compound

Table 7: Occurrence and selection of COPCs for Lake Surface Water in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Residential Recreational Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Metals										
Antimony (dissolved)	7440-36-0	0/3	nd	nd	µg/L	0.2 U – 0.2 U	0.2 U	1.5	no	bsl
Antimony (total)	7440-36-0	0/3	nd	nd	µg/L	0.2 U – 0.2 U	0.2 U	1.5	no	bsl
Arsenic (dissolved)	7440-38-2	3/3	0.9	1.0	µg/L	na	1.0	0.018	yes	asl
Arsenic (total)	7440-38-2	3/3	1.1	1.2	µg/L	na	1.2	0.018	yes	asl
Barium (dissolved)	7440-39-3	3/3	26	28	µg/L	na	28	730	no	bsl
Barium (total)	7440-39-3	3/3	30	31	µg/L	na	31	730	no	bsl
Cadmium (dissolved)	7440-43-9	0/3	nd	nd	µg/L	0.2 U – 0.2 U	0.2 U	1.8	no	bsl
Cadmium (total)	7440-43-9	0/3	nd	nd	µg/L	0.2 U – 0.2 U	0.2 U	1.8	no	bsl
Chromium (dissolved)	7440-47-3	0/3	nd	nd	µg/L	5 U – 5 U	5 U	11	no	bsl
Chromium (total)	7440-47-3	0/3	nd	nd	µg/L	5 U – 5 U	5 U	11	no	bsl
Cobalt (dissolved)	7440-48-4	0/3	nd	nd	µg/L	3 U – 3 U	3 U	1.1	yes	asl
Cobalt (total)	7440-48-4	0/3	nd	nd	µg/L	3 U – 3 U	3 U	1.1	yes	asl
Copper (dissolved)	7440-50-8	1/3	4	4	µg/L	2 U – 2 U	4	140	no	bsl
Copper (total)	7440-50-8	1/3	6	6	µg/L	2 U – 2 U	6	140	no	bsl
Lead (dissolved)	7439-92-1	0/3	nd	nd	µg/L	1 U – 1 U	1 U	15	no	bsl
Lead (total)	7439-92-1	0/3	nd	nd	µg/L	1 U – 1 U	1 U	15	no	bsl
Mercury (dissolved)	7439-97-6	0/3	nd	nd	µg/L	0.1 U – 0.1 U	0.1 U	1.1	no	bsl
Mercury (total)	7439-97-6	0/3	nd	nd	µg/L	0.1 U – 0.1 U	0.1 U	1.1	no	bsl
Nickel (dissolved)	7440-02-0	0/3	nd	nd	µg/L	10 U – 10 U	10 U	73	no	bsl
Nickel (total)	7440-02-0	0/3	nd	nd	µg/L	10 U – 10 U	10 U	73	no	bsl
Selenium (dissolved)	7782-49-2	0/3	nd	nd	µg/L	0.5 U – 0.5 U	0.5 U	18	no	bsl
Selenium (total)	7782-49-2	0/3	nd	nd	µg/L	0.5 U – 0.5 U	0.5 U	18	no	bsl
Vanadium (dissolved)	7440-62-2	0/3	nd	nd	µg/L	3 U – 3 U	3 U	18	no	bsl
Vanadium (total)	7440-62-2	0/3	nd	nd	µg/L	3 U – 3 U	3 U	18	no	bsl
Zinc (dissolved)	7440-66-6	0/3	nd	nd	µg/L	10 U – 10 U	10 U	1,100	no	bsl
Zinc (total)	7440-66-6	0/3	nd	nd	µg/L	10 U – 10 U	10 U	1,100	no	bsl
PAHs										
2-Methylnaphthalene	91-57-6	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	15	no	bsl
Acenaphthene	83-32-9	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	37	no	bsl
Acenaphthylene	208-96-8	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	37	no	bsl
Anthracene	120-12-7	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	180	no	bsl
Benzo(a)anthracene	56-55-3	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0038	yes	teq
Benzo(a)pyrene	50-32-8	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0029	yes	teq

Table 7: Occurrence and selection of COPCs for Lake Surface Water in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Residential Recreational Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
Benzo(b)fluoranthene	205-99-2	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0038	yes	teq
Benzo(g,h,i)perylene	191-24-2	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	na	no	ntx
Benzo(k)fluoranthene	207-08-9	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0038	yes	teq
Total benzofluoranthenes	56832-73-6	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	na	no	ntx
Chrysene	218-01-9	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0038	yes	teq
Dibenzo(a,h)anthracene	53-70-3	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0029	yes	teq
Dibenzofuran	132-64-9	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	na	no	ntx
Fluoranthene	206-44-0	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	130	no	bsl
Fluorene	86-73-7	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	24	no	bsl
Indeno(1,2,3-cd)pyrene	193-39-5	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0038	yes	teq
Naphthalene	91-20-3	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.12	no	bsl
Phenanthrene	85-01-8	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	na	no	ntx
Pyrene	129-00-0	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	110	no	bsl
Total HPAHs	na	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	na	no	ntx
Total LPAHs	na	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	na	no	ntx
cPAH TEQ	na	0/3	nd	nd	µg/L	0.0910 U – 0.0910 U	0.0910 U	0.0029	yes	asl
Total PAHs	na	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	na	no	ntx
Other SVOCs										
1,2,4-Trichlorobenzene	120-82-1	0/3	nd	nd	µg/L	5.0 U – 5.0 U	5.0 U	0.82	yes	asl
1,2-Dichlorobenzene	95-50-1	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	5	no	bsl
1,3-Dichlorobenzene	541-73-1	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	1.5	no	bsl
1,4-Dichlorobenzene	106-46-7	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.43	yes	asl
Hexachlorobenzene	118-74-1	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.00028	yes	asl
Hexachlorobutadiene	87-68-3	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.44	no	bsl
PCBs										
Aroclor-1016	12674-11-2	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.96	no	sum
Aroclor-1221	11104-28-2	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0068	no	sum
Aroclor-1232	11141-16-5	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.0068	no	sum
Aroclor-1242	53469-21-9	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.034	no	sum
Aroclor-1248	12672-29-6	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.034	no	sum
Aroclor-1254	11097-69-1	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.034	no	sum
Aroclor-1260	11096-82-5	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.034	no	sum
Total PCBs	1336-36-3	0/3	nd	nd	µg/L	0.10 U – 0.10 U	0.10 U	0.000064	yes	asl
Pesticides										
2,4'-DDD	53-19-0	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	sum
2,4'-DDE	3424-82-6	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	sum

Table 7: Occurrence and selection of COPCs for Lake Surface Water in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Residential Recreational Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
2,4'-DDT	789-02-6	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	sum
4,4'-DDD	72-54-8	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.00031	no	sum
4,4'-DDE	72-55-9	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.00022	no	sum
4,4'-DDT	50-29-3	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.00022	no	sum
Total DDTs	na	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.17	no	bsl
Aldrin	309-00-2	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.000049	yes	asl
Dieldrin	60-57-1	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.000052	yes	asl
Total aldrin/dieldrin	na	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	na	no	ntx
alpha-BHC	319-84-6	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.0026	yes	asl
beta-BHC	319-85-7	0/3	nd	nd	µg/L	0.0050 U – 0.024 U	0.024 U	0.0091	yes	asl
gamma-BHC	58-89-9	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.044	no	bsl
delta-BHC	319-86-8	0/3	nd	nd	µg/L	0.0050 U – 0.022 U	0.022 U	0.19	no	bsl
alpha-Chlordane	5103-71-9	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.16	no	bsl
gamma-Chlordane	5103-74-2	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.0008	yes	asl
Total chlordane	57-74-9	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.0008	yes	asl
alpha-Endosulfan	959-98-8	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	22	no	bsl
beta-Endosulfan	33213-65-9	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	22	no	bsl
Endosulfan sulfate	1031-07-8	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	22	no	bsl
Endrin	72-20-8	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.059	no	bsl
Endrin aldehyde	7421-93-4	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	0.29	no	bsl
Endrin ketone	53494-70-5	0/3	nd	nd	µg/L	0.010 U – 0.010 U	0.010 U	1.1	no	bsl
Heptachlor	76-44-8	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.000079	yes	asl
Heptachlor epoxide	1024-57-3	0/3	nd	nd	µg/L	0.0050 U – 0.0050 U	0.0050 U	0.000039	yes	asl
Methoxychlor	72-43-5	0/3	nd	nd	µg/L	0.050 U – 0.050 U	0.050 U	18	no	bsl
Toxaphene	8001-35-2	0/3	nd	nd	µg/L	0.50 U – 0.50 U	0.50 U	0.00028	yes	asl
VOCs										
1,1,1,2-Tetrachloroethane	630-20-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.52	yes	asl
1,1,1-Trichloroethane	71-55-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	84	no	bsl
1,1,2,2-Tetrachloroethane	79-34-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.067	yes	asl
1,1,2-Trichloroethane	79-00-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.24	yes	asl
1,1,2-Trichlorotrifluoroethane	76-13-1	0/3	nd	nd	µg/L	2.0 U – 2.0 U	2.0 U	5,900	no	bsl
1,1-Dichloroethane	75-34-3	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	2	no	bsl
1,1-Dichloroethene	75-35-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	7	no	bsl
1,1-Dichloropropene	563-58-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
1,2,3-Trichlorobenzene	87-61-6	0/3	nd	nd	µg/L	5.0 U – 5.0 U	5.0 U	na	no	ntx
1,2,3-Trichloropropane	96-18-4	0/3	nd	nd	µg/L	2.0 U – 2.0 U	2.0 U	0.0096	yes	asl

Table 7: Occurrence and selection of COPCs for Lake Surface Water in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Residential Recreational Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
1,2,4-Trimethylbenzene	95-63-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	1.2	no	bsl
1,2-Dibromo-3-chloropropane	96-12-8	0/3	nd	nd	µg/L	5.0 U – 5.0 U	5.0 U	0.00032	yes	asl
1,2-Dibromoethane (EDB)	106-93-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.0057	yes	asl
1,2-Dichloroethane	107-06-2	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.13	yes	asl
1,2-Dichloropropane	78-87-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.39	yes	asl
1,3,5-Trimethylbenzene	108-67-8	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	1.2	no	bsl
1,3-Dichloropropane	142-28-9	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
2,2-Dichloropropane	594-20-7	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
2-Chlorotoluene	95-49-8	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
2-Hexanone	591-78-6	0/3	nd	nd	µg/L	5.0 U – 5.0 U	5.0 U	na	no	ntx
4-Chlorotoluene	106-43-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
Acetone	67-64-1	3/3	5.4	6.5	µg/L	na	6.5	2,200	no	bsl
Benzene	71-43-2	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.35	yes	asl
Bromobenzene	108-86-1	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	2	no	bsl
Bromochloromethane	74-97-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
Bromodichloromethane	75-27-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.12	yes	asl
Bromoform	75-25-2	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	4.3	no	bsl
Bromomethane	74-83-9	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.85	yes	asl
Carbon disulfide	75-15-0	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	100	no	bsl
Carbon tetrachloride	56-23-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.17	yes	asl
Chlorobenzene	108-90-7	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	9	no	bsl
Chloroethane	75-00-3	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	3.9	no	bsl
Chloroform	67-66-3	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.18	yes	asl
Chloromethane	74-87-3	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	2.3	no	bsl
cis-1,2-Dichloroethene	156-59-2	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	6.1	no	bsl
cis-1,3-Dichloropropene	10061-01-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.34	yes	asl
p-Cymene	99-87-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
Dibromochloromethane	124-48-1	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.15	yes	asl
Dibromomethane	74-95-3	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
Dichlorodifluoromethane	75-71-8	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	39	no	bsl
Dichloromethane	75-09-2	0/3	nd	nd	µg/L	2.0 U – 2.0 U	2.0 U	4.1	no	bsl
Ethylbenzene	100-41-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	1.2	no	bsl
Isopropylbenzene	98-82-8	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	66	no	bsl
Methyl ethyl ketone	78-93-3	0/3	nd	nd	µg/L	5.0 U – 5.0 U	5.0 U	710	no	bsl
Methyl isobutyl ketone	108-10-1	0/3	nd	nd	µg/L	5.0 U – 5.0 U	5.0 U	200	no	bsl
n-Butylbenzene	104-51-8	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx

Table 7: Occurrence and selection of COPCs for Lake Surface Water in the Force Lake Recreational User RME Scenario

Chemical	CAS Number	Detection Frequency	Minimum Detected Conc.	Maximum Detected Conc.	Unit	Range of NDs	Value used for Screening	Residential Recreational Water RSL ^a	COPC Flag?	Rationale for Selection or Exclusion
n-Propylbenzene	103-65-1	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	6.1	no	bsl
sec-Butylbenzene	135-98-8	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	6.1	no	bsl
Styrene	100-42-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	100	no	bsl
tert-Butyl methyl ether	1634-04-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	11	no	bsl
tert-Butylbenzene	98-06-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	na	no	ntx
Tetrachloroethene	127-18-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.11	yes	asl
Toluene	108-88-3	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	230	no	bsl
trans-1,2-Dichloroethene	156-60-5	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	11	no	bsl
trans-1,3-Dichloropropene	10061-02-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.34	yes	asl
Trichloroethene	79-01-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.029	yes	asl
Trichlorofluoromethane	75-69-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	130	no	bsl
Vinyl acetate	108-05-4	0/3	nd	nd	µg/L	5.0 U – 5.0 U	5.0 U	41	no	bsl
Vinyl chloride	75-01-4	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	0.016	yes	asl
o-Xylene	95-47-6	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	21	no	sum
m,p-Xylene	108383/106423	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	21	no	sum
Total xylenes	1330-20-7	0/3	nd	nd	µg/L	1.0 U – 1.0 U	1.0 U	20	no	bsl
Petroleum^b										
TPH - Diesel range	na	0/1	nd	nd	mg/L	0.25 U – 0.25 U	0.25 U	0.88	no	bsl
TPH - Motor oil range	na	0/1	nd	nd	mg/L	0.50 U – 0.50 U	0.50 U	2.9	no	bsl

^a The residential/recreational water RSL is the lowest of EPA ambient water quality criteria (AWQC) for human water/ organism consumption and organism consumption (2009b), EPA water screening levels (2009d), EPA MCL or non-zero MCLGs (2009a), and DEQ human health occupational RBCs for the following four pathways: ingestion and inhalation from tap water, volatilization to outdoor air, vapor intrusion into buildings, and leaching to groundwater during excavation (2007). For TPHs, the screening level is the lowest occupational DEQ RBC (2003).

^b Aromatic and aliphatic TPHs were assumed to be equal to 15% and 85% of the TPH total for each of the three fractions (gasoline, diesel, and motor oil) based on ATSDR (1999). For the purposes of this HHRA, only aliphatic TPHs were carried forward as COPCs when above screening levels because the components of the aromatic TPHs (e.g., various PAHs and VOCs) were already assessed and thus the assessment of aromatic TPHs as an additional chemical group would double count risks.

asl – above screening level (selected as COPC)

BHC – benzene hexachloride

bsl – below screening level

COPC – contaminant of potential concern

CAS – Chemical Abstracts Service

cPAH – carcinogenic PAH

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

DL – detection limit

dw – dry weight

EDB – 1,2-dibromoethane

HPAH – high-molecular-weight PAH

J – estimated concentration

LPAH – low-molecular-weight PAH

MCL – maximum contaminant level

MCLG – maximum contaminant level goal

na – not available

ND – not detected

ntx – no toxicity information (not selected as COPC)

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RBC – risk-based concentration

RSL – regional screening level

sum – chemical included in sum and is not evaluated separately

SVOC – semivolatile organic compound

teq – chemical included in TEQ calculation and is not evaluated separately

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

U – not detected at given concentration

VOC – volatile organic compound

Table 8: Occurrence and selection of COPCs for Calculated Fish Tissue in the Force Lake Fish Consumer RME Scenario

Chemical	Unit (dw)	Detection Frequency	Sediment Concentrations				BSAF ^a	Fish Tissue		COPC Flag?	Rationale for Selection or Exclusion
			Minimum Detect	Maximum Detect	RL or Range of RLs	Sediment Screening Value		Calculated Fish Tissue ^b (mg/kg ww)	Fish RSL ^c (mg/kg ww)		
Metals											
Antimony	mg/kg	0/11	nd	nd	0.3 UJ - 1 UJ	1 UJ	1	0.20	0.0541	yes	asl
Arsenic	mg/kg	11/11	2.6	7	na	7	0.12	0.17	0.0021	yes	asl
Barium	mg/kg	11/11	128	220	na	220	1	44	27	yes	asl
Cadmium	mg/kg	8/11	2	2	0.3 U - 0.7 U	2	0.78	0.31	0.135	yes	asl
Chromium	mg/kg	11/11	7.7	34	na	34	0.043	0.29	0.406	no	bsl
Cobalt	mg/kg	11/11	7.3	15	na	15	1	3.0	0.0406	yes	asl
Copper	mg/kg	11/11	16.2	72	na	72	1	14	5.41	yes	asl
Lead	mg/kg	11/11	9	56	na	56	0.18	2.0	0.0000135	yes	asl
Mercury	mg/kg	1/11	0.2 J	0.2 J	0.06 U - 0.3 U	0.3 U	0.38	0.023	0.0135	yes	asl
Nickel	mg/kg	11/11	11	31	na	31	1	6.2	2.7	yes	asl
Selenium	mg/kg	0/11	nd	nd	0.7 U - 4 U	4 U	1	0.80	0.676	yes	asl
Vanadium	mg/kg	11/11	32.7	74	na	74	1	15	0.681	yes	asl
Zinc	mg/kg	11/11	80	229	na	229	1.8	84	40.6	yes	asl
PAHs											
2-Methylnaphthalene	µg/kg	7/11	7.9	31	5.0 U - 30 U	31	0.15	0.0026	0.541	no	bsl
Acenaphthene	µg/kg	5/11	5.0	11 JN	5.0 U - 30 U	30 U	0.031	0.00053	8.11	no	bsl
Acenaphthylene	µg/kg	3/11	5.0	7.0	5.0 U - 30 U	30 U	0.014	0.00023	8.11	no	bsl
Anthracene	µg/kg	6/11	5.9	26	5.0 U - 30 U	30 U	0.0078	0.00013	40.6	no	bsl
Benzo(a)anthracene	µg/kg	11/11	6.9	74	na	74	0.014	0.00057	0.00432	no	teq
Benzo(a)pyrene	µg/kg	11/11	7.9	83	na	83	0.0021	0.000098	0.000432	no	teq
Benzo(b)fluoranthene	µg/kg	11/11	8.4	71	na	71	0.0025	0.000098	0.00432	no	teq
Benzo(g,h,i)perylene	µg/kg	9/11	14	71	5.0 U	71	0.025	0.0010	na	no	ntx
Benzo(k)fluoranthene	µg/kg	11/11	8.4	71	na	71	0.0023	0.000092	0.0432	no	teq
Total benzofluoranthenes	µg/kg	11/11	16.8	142	na	142	1	0.080	na	no	ntx
Chrysene	µg/kg	11/11	9.4	110	na	110	0.010	0.00062	0.432	no	teq
Dibenzo(a,h)anthracene	µg/kg	3/11	5.4	6.5	5.0 U - 30 U	30 U	0.0022	0.000036	0.000432	no	teq
Dibenzofuran	µg/kg	3/11	5.0	7.4	5.0 U - 30 U	30 U	0.026	0.00044	na	no	ntx
Fluoranthene	µg/kg	11/11	20	190	na	190	0.0056	0.00060	5.41	no	bsl

Table 8: Occurrence and selection of COPCs for Calculated Fish Tissue in the Force Lake Fish Consumer RME Scenario

Chemical	Unit (dw)	Detection Frequency	Sediment Concentrations				BSAF ^a	Fish Tissue		COPC Flag?	Rationale for Selection or Exclusion
			Minimum Detect	Maximum Detect	RL or Range of RLs	Sediment Screening Value		Calculated Fish Tissue ^b (mg/kg ww)	Fish RSL ^c (mg/kg ww)		
Fluorene	µg/kg	6/11	5.9	26	5.0 U - 30 U	30 U	0.063	0.0011	5.41	no	bsl
Indeno(1,2,3-cd)pyrene	µg/kg	9/11	11	59	5.0 U	59	0.014	0.00048	0.00432	no	teq
Naphthalene	µg/kg	11/11	5.4	61	na	61	0.13	0.0046	2.7	no	bsl
Phenanthrene	µg/kg	11/11	15	120	na	120	0.024	0.0016	na	no	ntx
Pyrene	µg/kg	11/11	23	180	na	180	0.016	0.0016	4.06	no	bsl
Total HPAHs	µg/kg	11/11	84	910	na	910	1	0.51	na	no	ntx
Total LPAHs	µg/kg	11/11	20	230	na	230	1	0.13	na	no	ntx
cPAH TEQ	µg/kg	11/11	11.6	118	na	118	0.0021	0.00014	0.000432	no	bsl
Total PAHs	µg/kg	11/11	104	1,060	na	1,060	1	0.60	na	no	ntx
Other SVOCs											
1,2,4-Trichlorobenzene	µg/kg	0/11	nd	nd	5.3 U - 41 U	41 U	0.13	0.0030	0.876	no	bsl
1,2-Dichlorobenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	0.11	0.00052	12.2	no	bsl
1,3-Dichlorobenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	0.020	0.000094	na	no	ntx
1,4-Dichlorobenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	0.014	0.000063	0.584	no	bsl
Hexachlorobenzene	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	0.015	0.00010	0.00197	no	bsl
Hexachlorobutadiene	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	0.015	0.00010	0.0404	no	bsl
PCBs											
Aroclor-1016	µg/kg	0/11	nd	nd	32 U - 33 U	33 U	na	na	na	no	sum
Aroclor-1221	µg/kg	0/11	nd	nd	32 U - 33 U	33 U	na	na	na	no	sum
Aroclor-1232	µg/kg	0/11	nd	nd	32 U - 33 U	33 U	na	na	na	no	sum
Aroclor-1242	µg/kg	0/11	nd	nd	32 U - 33 U	33 U	na	na	na	no	sum
Aroclor-1248	µg/kg	0/11	nd	nd	32 U - 33 U	33 U	na	na	na	no	sum
Aroclor-1254	µg/kg	7/11	58	71	32 U - 49 U	71	na	na	0.0016	no	sum
Aroclor-1260	µg/kg	7/11	35	60	32 U - 33 U	60	na	na	na	no	sum
Total PCBs	µg/kg	7/11	93	131	32 U - 49 U	131	6.45	0.48	0.00158	yes	asl
Pesticides											
2,4'-DDD	µg/kg	8/11	8.6 JN	61 JN	4.8 U - 25 U	61 JN	0.045	0.0015	0.0131	no	sum
2,4'-DDE	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	2	0.028	na	no	sum
2,4'-DDT	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	1.3	0.018	0.00928	yes	sum
4,4'-DDD	µg/kg	11/11	11 J	47	na	47	0.83	0.022	0.0131	yes	sum

Table 8: Occurrence and selection of COPCs for Calculated Fish Tissue in the Force Lake Fish Consumer RME Scenario

Chemical	Unit (dw)	Detection Frequency	Sediment Concentrations				BSAF ^a	Fish Tissue		COPC Flag?	Rationale for Selection or Exclusion
			Minimum Detect	Maximum Detect	RL or Range of RLs	Sediment Screening Value		Calculated Fish Tissue ^b (mg/kg ww)	Fish RSL ^c (mg/kg ww)		
4,4'-DDE	µg/kg	11/11	9.1	150	na	150	5.0	0.42	na	no	sum
4,4'-DDT	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	6.25	0.088	0.00928	yes	sum
Total DDTs	µg/kg	11/11	22 J	250	na	250	1.96	0.28	0.00928	yes	asl
Aldrin	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	1	0.0068	0.000186	yes	asl
Dieldrin	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	2.2	0.031	0.000197	yes	asl
Total aldrin/dieldrin	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	1	0.014	na	no	ntx
alpha-BHC	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	1	0.0068	0.000501	yes	asl
beta-BHC	µg/kg	0/11	nd	nd	2.4 U - 23 U	23 U	1	0.013	0.00175	yes	asl
gamma-BHC	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	1	0.0068	0.00287	yes	asl
delta-BHC	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	1	0.0068	na	no	ntx
alpha-Chlordane	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	1.5	0.0099	0.00901	yes	asl
gamma-Chlordane	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	1.1	0.0077	0.00901	no	bsl
Total chlordane	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	26	0.18	0.00901	yes	asl
alpha-Endosulfan	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	1	0.0068	0.811	no	bsl
beta-Endosulfan	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	1	0.014	0.811	no	bsl
Endosulfan sulfate	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	1	0.014	0.811	no	bsl
Endrin	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	1	0.014	0.0406	no	bsl
Endrin aldehyde	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	1	0.014	0.0406	no	bsl
Endrin ketone	µg/kg	0/11	nd	nd	4.8 U - 25 U	25 U	1	0.014	0.0406	no	bsl
Heptachlor	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	0.13	0.00088	0.000701	yes	asl
Heptachlor epoxide	µg/kg	0/11	nd	nd	2.4 U - 12 U	12 U	29	0.20	0.000347	yes	asl
Methoxychlor	µg/kg	0/11	nd	nd	24 U - 120 U	120 U	1	0.068	0.676	no	bsl
Toxaphene	µg/kg	0/11	nd	nd	970 U - 5,000 U	5,000 U	1	2.8	0.00287	yes	asl
VOCs											
1,1,1,2-Tetrachloroethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.121	no	bsl
1,1,1-Trichloroethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	270	no	bsl
1,1,2,2-Tetrachloroethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0158	no	bsl
1,1,2-Trichloroethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0553	no	bsl
1,1,2-Trichlorotrifluoroethane	µg/kg	0/11	nd	nd	2.1 U - 16 U	16 U	1	0.0090	na	no	ntx
1,1-Dichloroethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.553	no	bsl

Table 8: Occurrence and selection of COPCs for Calculated Fish Tissue in the Force Lake Fish Consumer RME Scenario

Chemical	Unit (dw)	Detection Frequency	Sediment Concentrations				BSAF ^a	Fish Tissue		COPC Flag?	Rationale for Selection or Exclusion
			Minimum Detect	Maximum Detect	RL or Range of RLs	Sediment Screening Value		Calculated Fish Tissue ^b (mg/kg ww)	Fish RSL ^c (mg/kg ww)		
1,1-Dichloroethene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
1,1-Dichloropropene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
1,2,3-Trichlorobenzene	µg/kg	0/11	nd	nd	5.3 U - 41 U	41 U	1	0.023	na	no	ntx
1,2,3-Trichloropropane	µg/kg	0/11	nd	nd	2.1 U - 16 U	16 U	1	0.0090	0.000451	yes	yes
1,2,4-Trimethylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
1,2-Dibromo-3-chloropropane	µg/kg	0/11	nd	nd	5.3 U - 41 U	41 U	1	0.023	0.00394	yes	yes
1,2-Dibromoethane (EDB)	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
1,2-Dichloroethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0347	no	bsl
1,2-Dichloropropane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0876	no	bsl
1,3,5-Trimethylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	6.76	no	bsl
1,3-Dichloropropane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	2.7	no	bsl
2,2-Dichloropropane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
2-Chlorotoluene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
2-Hexanone	µg/kg	0/11	nd	nd	5.3 U - 41 U	41 U	1	0.023	na	no	ntx
4-Chlorotoluene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Acetone	µg/kg	10/11	78 JN	1,100	35 U	1,100	1	0.62	122	no	bsl
Benzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0574	yes	cac
Bromobenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	2.7	no	bsl
Bromochloromethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Bromodichloromethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0509	no	bsl
Bromoform	µg/kg	0/10	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.399	no	bsl
Bromomethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.189	no	bsl
Carbon disulfide	µg/kg	11/11	4.9	140	na	140	1	0.079	13.5	no	bsl
Carbon tetrachloride	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0243	no	bsl
Chlorobenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	2.7	no	bsl
Chloroethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Chloroform	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.102	no	bsl
Chloromethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
cis-1,2-Dichloroethene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
cis-1,3-Dichloropropene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx

Table 8: Occurrence and selection of COPCs for Calculated Fish Tissue in the Force Lake Fish Consumer RME Scenario

Chemical	Unit (dw)	Detection Frequency	Sediment Concentrations				BSAF ^a	Fish Tissue		COPC Flag?	Rationale for Selection or Exclusion
			Minimum Detect	Maximum Detect	RL or Range of RLs	Sediment Screening Value		Calculated Fish Tissue ^b (mg/kg ww)	Fish RSL ^c (mg/kg ww)		
p-Cymene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Dibromochloromethane	µg/kg	0/10	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.0376	no	bsl
Dibromomethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Dichlorodifluoromethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	27	no	bsl
Dichloromethane	µg/kg	0/11	nd	nd	2.1 U - 16 U	16 U	1	0.0090	na	no	ntx
Ethylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.287	no	bsl
Isopropylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Methyl ethyl ketone	µg/kg	10/11	9.4	140	5.3 U	140	1	0.079	81.1	no	bsl
Methyl isobutyl ketone	µg/kg	0/11	nd	nd	5.3 U - 41 U	41 U	1	0.023	na	no	ntx
n-Butylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
n-Propylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
sec-Butylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Styrene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	27	no	bsl
tert-Butyl methyl ether	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
tert-Butylbenzene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Tetrachloroethene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Toluene	µg/kg	3/11	1.2	17	6.0 U - 8.2 U	17	1	0.0096	10.8	no	bsl
trans-1,2-Dichloroethene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
trans-1,3-Dichloropropene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	na	no	ntx
Trichloroethene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.243	no	bsl
Trichlorofluoromethane	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	40.6	no	bsl
Vinyl acetate	µg/kg	0/10	nd	nd	5.3 U - 43 U	43 U	1	0.024	135	no	bsl
Vinyl chloride	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	0.00438	yes	asl
o-Xylene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	27	no	sum
m,p-Xylene	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	27	no	sum
Total xylenes	µg/kg	0/11	nd	nd	1.1 U - 8.2 U	8.2 U	1	0.0046	27	no	bsl
Petroleum											
TPH - Gasoline range	mg/kg	1/11	31	31	7.7 U - 80 U	80 U	1	45	na	no	ntx
TPH - Diesel range	mg/kg	11/11	16	270	na	270	1	150	na	no	ntx
TPH - Motor oil range	mg/kg	11/11	130	2,000	na	2,000	1	1,100	na	no	ntx

^a BSAF units are dw/dw for metals, and are lipid/OC for all other chemicals.

^b Fish tissue concentrations are estimated based on the sediment concentrations and BSAFs presented in this table (see Attachment 2 for additional information regarding the methodology used to calculate tissue concentrations).

^c Fish RSLs are taken from EPA Region 3 RBC tables (2009c).

asl – above screening level (selected as COPC)

BSAF – biota sediment accumulation factor

BHC – benzene hexachloride

bsl – below screening level

cac – Class A carcinogen (selected as COPC)

COPC – contaminant of potential concern

cPAH – carcinogenic PAH

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EDB – 1,2-dibromoethane

HPAH – high-molecular-weight PAH

J – estimated concentration

LPAH – low-molecular-weight PAH

na – not available

nd – not detected

ntx – no toxicity information (not selected as COPC)

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

RSL – regional screening level

sum – chemical included in sum and is not evaluated separately

SVOC – semivolatile organic compound

teq – chemical included in TEQ calculation and is not evaluated separately

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

U – not detected at given concentration

VOC – volatile organic compound

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ATTACHMENT 4 – CALCULATION OF OUTDOOR AIR VAPOR CONCENTRATIONS FOR INHALATION RISKS

This attachment presents the calculation of volatilized contaminants of potential concern (COPC) concentrations in air for the industrial (construction/trenching) worker reasonable maximum exposure (RME) scenario and the future outdoor worker RME scenario. Concentrations in air were calculated using equations based on a series of commonly used models. These models have been compiled in a modeling software package called Risk-Integrated Software for Cleanup (RISC) (Spence and Walden 2001). For convenience, RISC was used to perform these calculations, but these calculations can also be made without this software using the equations presented in this attachment. Additional references for the equations can be found in the RISC user's manual (Spence and Walden 2001).

Section 1.0 presents the equations used to calculate outdoor air concentrations based on soil data, and Section 2.0 presents the equations used to calculate outdoor air concentrations based on groundwater data. Tables in these sections present the necessary COPC-specific parameter values and values calculated using the equations in this attachment for the industrial (construction/trenching) worker RME and the future outdoor worker RME scenarios. Only COPCs that might be expected to volatilize significantly because of their diffusivity in air or water are presented. None of the inorganic COPCs fit these criteria, and thus they are not presented.

1.0 Calculation of Outdoor Air Concentrations from Soil Data

Soil is commonly characterized as a three-part system consisting of solid, gaseous, and aqueous states. Chemical transfer between states typically occurs through the aqueous state, which is often referred to as porewater. Consequently, when starting with soil data, the first step in calculating outdoor air concentrations is to convert the soil concentrations to dissolved-phase concentrations within the porewater (Tables 1 and 2). This is a two-step process because it is necessary to check that the calculated dissolved-phase concentration is not greater than the COPC's solubility.

Table 1. Model Inputs and Outputs for the Prediction of COPC Concentrations in Vapor from Soil for the Industrial (Construction/Trenching) Worker RME Scenario

Facility Soil COPC	Chemical-Specific Inputs ^a						Calculated Values							
	C _s (soil EPC, mg/kg dw)	K _{oc} (organic carbon partitioning coefficient, ml/g)	K _H (Henry's Law constant, unitless)	S _{eff} (effective solubility, mg/L)	D _{air} (molecular diffusion coefficient in air, cm ² /s)	D _{water} (molecular diffusion coefficient in water, cm ² /s)	C _{ws} (dissolved-phase conc., mg/L) (Equation 1a)	Is C _{ws} greater than the COPC's solubility?	C _H ^{max} (max source vapor conc., g/cm ³) (Equation 1b)	Selected C _{ws} Value (dissolved-phase conc., mg/L) (Equation 1a)	C _{vs} (vapor conc. at source, g/cm ³) (Equation 2)	D _{eff} (effective diffusion coefficient) (Equation 3)	F (vapor flux rate, g/cm ² /s) (Equation 4)	C _{outdoor} (estimated soil vapor EPC, mg/m ³) (Equation 5)
Naphthalene	2.0	2,000	0.0198	31	0.059	7.50 × 10 ⁻⁶	0.10	no (C _{ws} < S _{eff})	na	0.10	2.0 × 10 ⁻⁹	0.0046	3.0 × 10 ⁻¹⁴	7.5 × 10 ⁻⁷
cPAH TEQ ^b	0.95	1,000,000	0.0000463	0.00162	0.043	9.00 × 10 ⁻⁶	0.000095	no (C _{ws} < S _{eff})	na	0.000095	4.4 × 10 ⁻¹⁵	0.0052	7.7 × 10 ⁻²⁰	1.9 × 10 ⁻¹²
Total PCBs	3.4	310,000	0.0111	0.42	0.100	7.95 × 10 ⁻⁶	0.0011	no (C _{ws} < S _{eff})	na	0.0011	1.2 × 10 ⁻¹¹	0.0078	3.2 × 10 ⁻¹⁶	7.9 × 10 ⁻⁹
Total DDTs ^b	11	2,630,000	0.000332	0.025	0.0137	4.95 × 10 ⁻⁶	0.00042	no (C _{ws} < S _{eff})	na	0.00042	1.4 × 10 ⁻¹³	0.0012	5.6 × 10 ⁻¹⁹	1.4 × 10 ⁻¹¹
1,1-Dichloroethane	0.68	32	0.23	5,060	0.0742	1.05 × 10 ⁻⁵	1.5	no (C _{ws} < S _{eff})	na	1.5	3.5 × 10 ⁻⁷	0.0058	6.7 × 10 ⁻¹²	1.7 × 10 ⁻⁴
1,2,4-Trimethylbenzene ^b	5.3	2,000	0.0198	31	0.059	7.50 × 10 ⁻⁶	0.26	no (C _{ws} < S _{eff})	na	0.26	5.2 × 10 ⁻⁹	0.0046	8.0 × 10 ⁻¹⁴	2.0 × 10 ⁻⁶
1,3,5-Trimethylbenzene ^b	1.3	2,000	0.0198	31	0.059	7.50 × 10 ⁻⁶	0.065	no (C _{ws} < S _{eff})	na	0.065	1.3 × 10 ⁻⁹	0.0046	2.0 × 10 ⁻¹⁴	4.9 × 10 ⁻⁷
Benzene	0.33	59	0.23	1,750	0.088	9.80 × 10 ⁻⁶	0.46	no (C _{ws} < S _{eff})	na	0.46	1.1 × 10 ⁻⁷	0.0068	2.4 × 10 ⁻¹²	6.0 × 10 ⁻⁵
Chlorobenzene	0.22	22	0.15	472	0.073	8.70 × 10 ⁻⁶	0.66	no (C _{ws} < S _{eff})	na	0.66	9.9 × 10 ⁻⁸	0.0057	1.9 × 10 ⁻¹²	4.7 × 10 ⁻⁵
cis-1,2-Dichloroethene	8.7	36	0.17	3,500	0.0736	1.13 × 10 ⁻⁵	18	no (C _{ws} < S _{eff})	na	18	3.1 × 10 ⁻⁶	0.0057	5.9 × 10 ⁻¹¹	1.5 × 10 ⁻³
Dichloromethane	0.02	12	0.0898	13,000	0.10	1.2 × 10 ⁻⁵	0.090	no (C _{ws} < S _{eff})	na	0.090	8.1 × 10 ⁻⁹	0.0078	2.1 × 10 ⁻¹³	5.2 × 10 ⁻⁶
Ethylbenzene	1.9	360	0.32	169	0.075	7.80 × 10 ⁻⁶	0.51	no (C _{ws} < S _{eff})	na	0.51	1.6 × 10 ⁻⁷	0.0058	3.2 × 10 ⁻¹²	7.9 × 10 ⁻⁵
trans-1,2-Dichloroethene	5.5	53	0.39	6,300	0.0707	1.19 × 10 ⁻⁵	8.1	no (C _{ws} < S _{eff})	na	8.1	3.1 × 10 ⁻⁶	0.0055	5.8 × 10 ⁻¹¹	1.4 × 10 ⁻³
Trichloroethene	0.16	170	0.42	1,100	0.079	9.10 × 10 ⁻⁶	0.086	no (C _{ws} < S _{eff})	na	0.086	3.6 × 10 ⁻⁸	0.0061	7.4 × 10 ⁻¹³	1.9 × 10 ⁻⁵
Vinyl chloride	1.2	19	1.11	2,760	0.11	1.20 × 10 ⁻⁶	2.6	no (C _{ws} < S _{eff})	na	2.6	2.9 × 10 ⁻⁶	0.0085	8.2 × 10 ⁻¹¹	2.1 × 10 ⁻³
Total xylenes	10	240	0.29	198	0.072	8.50 × 10 ⁻⁶	3.9	no (C _{ws} < S _{eff})	na	3.9	1.1 × 10 ⁻⁶	0.0056	2.1 × 10 ⁻¹¹	5.3 × 10 ⁻⁴
TPH-gasoline (aliphatic) ^c	430	4,000	51	5.4	0.10	1.0 × 10 ⁻⁵	8.9	yes (C _{ws} > S _{eff})	275	5.7	2.9 × 10 ⁻⁴	0.0078	7.5 × 10 ⁻⁹	1.9 × 10 ⁻¹

^a Soil EPCs were calculated as described in Section 3.0 of the HHRA. The values for the other model inputs were from RISC (Spence and Walden 2001) and/or from EPA (1996).

^b As a health-protective approach, structurally similar chemicals were selected as surrogates (i.e., the surrogate chemical was generally considered to be more toxic than the COPC it was representing). Benzo(a)pyrene was used for cPAH TEQ, 4,4'-DDT was used for total DDTs, and naphthalene was used for trimethylbenzenes.

^c The estimated soil vapor EPC was based on TPH-gasoline (aliphatic) with 6 to 8 carbon atoms.

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

EPA – US Environmental Protection Agency

EPC – exposure point concentration

HHRA – human health risk assessment

na – not applicable

PCB – polychlorinated biphenyl

RISC – Risk-Integrated Software for Cleanup

RME – reasonable maximum exposure

TEQ – toxic equivalent

TPH – total petroleum hydrocarbon

Table 2. Model Inputs and Outputs for the Prediction of COPC Concentrations in Vapor from Soil for the Future Outdoor Worker RME Scenario

Facility Soil COPC	Chemical-Specific Inputs ^a						Calculated Values							
	C _s (soil EPC, mg/kg dw)	K _{oc} (organic carbon partitioning coefficient, ml/g)	K _H (Henry's Law constant, unitless)	S _{eff} (effective solubility, mg/L)	D _{air} (molecular diffusion coefficient in air, cm ² /s)	D _{water} (molecular diffusion coefficient in water, cm ² /s)	C _{ws} (dissolved-phase conc., mg/L) (Equation 1a)	Is C _{ws} greater than the COPC's solubility?	C _H ^{max} (max source vapor conc., g/cm ³) (Equation 1b)	Selected C _{ws} Value (dissolved-phase conc., mg/L) (Equation 1a)	C _{vs} (vapor conc. at source, g/cm ³) (Equation 2)	D _{eff} (effective diffusion coefficient) (Equation 3)	F (vapor flux rate, g/cm ² /s) (Equation 4)	C _{outdoor} (estimated soil vapor EPC, mg/m ³) (Equation 5)
Naphthalene	2.6	2,000	0.0198	31	0.059	7.50 × 10 ⁻⁶	0.13	no (C _{ws} < S _{eff})	na	0.13	2.6 × 10 ⁻⁹	0.0046	3.9 × 10 ⁻¹⁴	9.8 × 10 ⁻⁷
cPAH TEQ ^b	1.1	1,000,000	0.0000463	0.00162	0.043	9.00 × 10 ⁻⁶	0.00011	no (C _{ws} < S _{eff})	na	0.00011	5.1 × 10 ⁻¹⁵	0.0052	8.9 × 10 ⁻²⁰	2.2 × 10 ⁻¹²
Total PCBs	5.2	310,000	0.0111	0.42	0.100	7.95 × 10 ⁻⁶	0.0017	no (C _{ws} < S _{eff})	na	0.0017	1.9 × 10 ⁻¹¹	0.0078	4.8 × 10 ⁻¹⁶	1.2 × 10 ⁻⁸
Total DDTs ^b	16	2,630,000	0.000332	0.025	0.0137	4.95 × 10 ⁻⁶	0.00061	no (C _{ws} < S _{eff})	na	0.00061	2.0 × 10 ⁻¹³	0.0012	8.1 × 10 ⁻¹⁹	2.0 × 10 ⁻¹¹
1,1-Dichloroethane	0.68	32	0.23	5,060	0.0742	1.05 × 10 ⁻⁵	1.5	no (C _{ws} < S _{eff})	na	1.5	3.5 × 10 ⁻⁷	0.0058	6.7 × 10 ⁻¹²	1.7 × 10 ⁻⁴
1,2,4-Trimethylbenzene ^b	13	2,000	0.0198	31	0.059	7.50 × 10 ⁻⁶	0.65	no (C _{ws} < S _{eff})	na	0.65	1.3 × 10 ⁻⁸	0.0046	2.0 × 10 ⁻¹³	4.9 × 10 ⁻⁶
1,3,5-Trimethylbenzene ^b	3.0	2,000	0.0198	31	0.059	7.50 × 10 ⁻⁶	0.15	no (C _{ws} < S _{eff})	na	0.15	3.0 × 10 ⁻⁹	0.0046	4.5 × 10 ⁻¹⁴	1.1 × 10 ⁻⁶
Benzene	0.51	59	0.228	1,750	0.088	9.80 × 10 ⁻⁶	0.71	no (C _{ws} < S _{eff})	na	0.71	1.6 × 10 ⁻⁷	0.0068	3.7 × 10 ⁻¹²	9.3 × 10 ⁻⁵
cis-1,2-Dichloroethene	130	36	0.167	3,500	0.074	1.1 × 10 ⁻⁵	273	no (C _{ws} < S _{eff})	na	273	4.6 × 10 ⁻⁵	0.0057	8.8 × 10 ⁻¹⁰	2.2 × 10 ⁻²
Dichloromethane	0.047	12	0.0898	13,000	0.10	1.2 × 10 ⁻⁵	0.211	no (C _{ws} < S _{eff})	na	0.21	1.9 × 10 ⁻⁸	0.0078	4.9 × 10 ⁻¹³	1.2 × 10 ⁻⁵
Ethylbenzene	3.1	360	0.32	169	0.075	7.80 × 10 ⁻⁶	0.83	no (C _{ws} < S _{eff})	na	0.83	2.7 × 10 ⁻⁷	0.0058	5.1 × 10 ⁻¹²	1.3 × 10 ⁻⁴
trans-1,2-Dichloroethene	5.5	53	0.39	6,300	0.0707	1.19 × 10 ⁻⁵	8.1	no (C _{ws} < S _{eff})	na	8.1	3.1 × 10 ⁻⁶	0.0055	5.8 × 10 ⁻¹¹	1.4 × 10 ⁻³
Trichloroethene	0.27	170	0.42	1,100	0.079	9.10 × 10 ⁻⁶	0.15	no (C _{ws} < S _{eff})	na	0.15	6.1 × 10 ⁻⁸	0.0061	1.2 × 10 ⁻¹²	3.1 × 10 ⁻⁵
Vinyl chloride	1.2	19	1.11	2,760	0.011	1.2 × 10 ⁻⁶	2.6	no (C _{ws} < S _{eff})	na	2.6	2.9 × 10 ⁻⁶	0.0085	8.2 × 10 ⁻¹¹	2.1 × 10 ⁻³
Total xylenes	16	240	0.29	198	0.072	8.50 × 10 ⁻⁶	6.3	no (C _{ws} < S _{eff})	na	6.3	1.8 × 10 ⁻⁶	0.0056	3.4 × 10 ⁻¹¹	8.5 × 10 ⁻⁴
TPH-gasoline (aliphatic) ^c	660	4,000	51	5.4	0.10	1.0 × 10 ⁻⁵	13.6	yes (C _{ws} > S _{eff})	275	5.7	2.9 × 10 ⁻⁴	0.0078	7.5 × 10 ⁻⁹	1.9 × 10 ⁻¹

^a Soil EPCs were calculated as described in Section 3.0 of the HHRA. The values for the other model inputs were from RISC (Spence and Walden 2001) and/or from EPA (1996).

^b As a health-protective approach, structurally similar chemicals were selected as surrogates (i.e., the surrogate chemical was generally considered to be more toxic than the COPC it was representing). Benzo(a)pyrene was used for cPAH TEQ, 4,4'-DDT was used for total DDTs, and naphthalene was used for trimethylbenzenes.

^c The estimated soil vapor EPC was based on TPH-gasoline (aliphatic) with 6 to 8 carbon atoms.

COPC – contaminant of potential concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
DDT – dichlorodiphenyltrichloroethane
dw – dry weight

EPA – US Environmental Protection Agency
EPC – exposure point concentration
HHRA – human health risk assessment

na – not applicable
PCB – polychlorinated biphenyl
RISC – Risk-Integrated Software for Cleanup

RME – reasonable maximum exposure
TEQ – toxic equivalent
TPH – total petroleum hydrocarbon

First, Equation 1a is used to calculate the initial dissolved-phase concentration at the source from the input soil concentration using the equilibrium partitioning theory.

$$C_{ws} = \frac{C_s \rho_b}{\theta_a K_H + \theta_w + \rho_b F_{oc} K_{oc}} \quad \text{Equation 1a}$$

Where:

- C_{ws} = dissolved-phase concentration at the source (mg/L)
- C_s = COPC concentration in soil, equal to the soil EPC presented in Tables 1 and 2 (mg/kg)
- ρ_b = soil bulk density of the source area (1.7 g/cm³)
- K_H = COPC-specific Henry's Law constant [(mg/L vapor)/(mg/L water)]
- θ_a = vadose zone air-filled porosity (0.28 cm³ of air/cm³ total soil volume)
- θ_w = vadose zone water-filled porosity (0.15 cm³ of water/cm³ total soil volume)
- F_{oc} = fraction organic carbon in soil (0.01 g organic carbon/g soil)
- K_{oc} = COPC-specific organic carbon partition coefficient (ml/g)

The values for soil bulk density (1.7) and fraction organic carbon (0.01) used in this equation were default values from the RISC model that are typical of soil (Spence and Walden 2001). Region-specific values for air-filled porosity (0.28) and water-filled porosity (0.15) in the vadose zone were taken from the US Environmental Protection Agency (EPA) (1996).

Next, the dissolved-phase concentration at the source (C_{ws}) calculated using Equation 1a is compared with the COPC-specific effective solubility (Tables 1 and 2) to determine whether the calculated dissolved-phase concentration is greater than the COPC's solubility.

- **Source concentration less than effective solubility:** If the C_{ws} is lower than the COPC-specific effective solubility, C_{ws} (from Equation 1a) is used in Equation 2 to calculate the vapor concentration at the source.
- **Source concentration greater than effective solubility:** If the C_{ws} is greater than the COPC-specific effective solubility, the C_{ws} must be re-calculated because it is not possible for a COPC to be present in the dissolved phase at a concentration greater than its solubility.

If the source concentration (C_{ws}) is greater than the effective solubility, Equation 1b is used to calculate the maximum source vapor concentration (C_H^{\max}), which reflects the highest soil concentration that can be dissolved in water.

$$C_H^{\max} = E_{sol} K_H \quad \text{Equation 1b}$$

Where:

- C_H^{\max} = maximum source vapor concentration (g/cm³)
- E_{eff} = COPC-specific effective solubility presented in Tables 1 and 2 (mg/L)
- K_H = COPC-specific Henry's Law constant [(mg/L vapor)/(mg/L water)]

The C_H^{\max} value calculated using Equation 1b is then used in place of the COPC concentration in soil (C_s) in Equation 1a to determine the dissolved-phase concentration at the source (C_{ws}) to be used in Equation 2.

Once the appropriate dissolved-phase concentration at the source (C_{ws}) is determined, Equation 2 is used to calculate the initial vapor concentration at the source using Henry's Law, which states that the solubility of a gas in a liquid at a particular temperature is proportional to the pressure of that gas above the liquid.

$$C_{vs} = K_H C_{ws} \left(\frac{l}{1,000 \text{ cm}^3} \right) \left(\frac{g}{1,000 \text{ mg}} \right) \quad \text{Equation 2}$$

Where:

- C_{vs} = vapor concentration at the source (g/cm^3)
- K_H = COPC-specific Henry's Law constant $[(\text{mg}/\text{L vapor})/(\text{mg}/\text{L water})]$
- C_{ws} = dissolved-phase concentration at the source calculated using Equation 1a (mg/L)

Next, Equation 3 is used to calculate the effective diffusion coefficient within the soil vadose zone, which describes the tendency of individual molecules or ions to migrate through soil.

$$D_{\text{eff}} = D_{\text{air}} \left(\frac{\theta_a^{10/3}}{\theta_t^2} \right) + D_{\text{water}} \frac{1}{K_H} \left(\frac{\theta_w^{10/3}}{\theta_t^2} \right) \quad \text{Equation 3}$$

Where:

- D_{eff} = effective diffusion coefficient (cm^2/s)
- D_{air} = COPC-specific molecular diffusion coefficient in air (cm^2/s)
- θ_a = vadose zone air-filled porosity (0.28 cm^3 of air/ cm^3 total soil volume)
- θ_t = total porosity (0.43 cm^3 of pores/ cm^3 total soil volume)
- D_{water} = COPC-specific molecular diffusion coefficient in water (cm^2/s)
- K_H = COPC-specific Henry's Law constant $[(\text{mg}/\text{L vapor})/(\text{mg}/\text{L water})]$
- θ_w = vadose zone water-filled porosity (0.15 cm^3 of water/ cm^3 total soil volume)

COPC-specific values for molecular diffusion coefficients in air (D_{air}) and water (D_{water}) were taken from EPA (1996) (Tables 1 and 2). The value used for total porosity (0.43) is the sum of the values used for air-filled and water-filled porosity for the vadose zone defined for Equation 1a.

Equation 4 is then used to calculate the volatile flux rate (i.e., change in mass per area over time) of COPCs from soil.

$$F = D_{\text{eff}} \left(\frac{C_{vs} - C_{\text{amb}}}{X_{\text{diff}}} \right) \quad \text{Equation 4}$$

Where:

- F = vapor flux rate ($\text{g}/\text{cm}^2\text{-s}$)
- D_{eff} = effective diffusion coefficient calculated using Equation 3 (cm^2/s)
- C_{vs} = vapor concentration at the source calculated using Equation 2 (g/cm^3)
- C_{amb} = ambient vapor concentration ($0 \text{ g}/\text{cm}^3$)
- X_{diff} = diffusion distance (300 cm)

For this human health risk assessment (HHRA), the ambient vapor concentration (C_{amb}) was assumed to be zero as a health-protective assumption. The diffusion distance (X_{diff}) was 300 cm, which is the sum of the depth of a shallow trench (~120 cm) and the height of an average-sized person (180 cm).

The last step is to calculate the outdoor air concentration using Equation 5. Outdoor air concentrations are calculated using a simple model that describes the wind-driven flux of COPCs through an imaginary box above the contaminated soil in what is considered the “breathing zone.”

$$C_{\text{outdoor}} = \frac{F \times L}{u \times H} \left(\frac{\text{m}}{100 \text{ cm}} \right) \left(\frac{1,000 \text{ mg}}{\text{g}} \right) \left(\frac{10^6 \text{ cm}^3}{\text{m}^3} \right) \quad \text{Equation 5}$$

Where:

- C_{outdoor} = concentration in outdoor air (mg/m³)
- F = vapor flux rate calculated using Equation 4 (g/cm²-s)
- L = length of box in the direction of air flow (parallel to the wind) (10 m)
- H = height of box (2 m)
- u = wind speed (2 m/s)

The default parameters values provided in RISC were used to calculate outdoor air concentrations (Spence and Walden 2001). Box length was equal to 10 m, box height was equal to 2 m (height of a person rounded to one significant figure), and the wind speed was equal to 2 m/s.

Tables 1 and 2 present the outdoor air concentrations calculated from soil concentrations for the industrial (construction/trenching) worker RME scenario and the future outdoor worker RME scenario. These concentrations were used in the HHRA to calculate risks based on exposure to Facility soil for these scenarios.

2.0 Calculation of Outdoor Air Concentrations from Groundwater Data

Air concentrations can also be calculated based on groundwater data. When starting with groundwater data, the first step is to compare the COPC-specific effective solubility with the groundwater concentration (Table 3). The lower of these values is then used in Equation 6 (i.e., a COPC cannot be present in the dissolved phase at a concentration higher than its effective solubility).

Table 3. Model Inputs and Outputs for the Prediction of COPC Concentrations in Vapor from Groundwater for the Industrial (Construction/Trenching) Worker RME Scenario

Groundwater COPC	Chemical-Specific Inputs ^a					Calculated Values						
	C _{ws} (ground-water EPC, mg/L)	Effective Solubility (mg/L)	K _H (Henry's Law constant, unitless)	D _{air} (molecular diffusion coefficient in Air, cm ² /s)	D _{water} (molecular diffusion coefficient in water, cm ² /s)	Selected C _{ws} Value (greater of C _{ws} and effective solubility concentration, mg/L)	C _{vs} (vapor conc. at source, g/cm ³) (Equation 6)	D _{eff-v} (effective diffusion coefficient for the vadose zone, cm ² /s) (Equation 7a)	D _{eff-cap} (effective diffusion coefficient for the capillary fringe, cm ² /s) (Equation 7b)	D _{eff} (effective diffusion coefficient within groundwater cm ² /s) (Equation 8)	F (vapor flux rate, g/cm ² -s) (Equation 4)	C _{outdoor} (estimated groundwater vapor EPC, mg/m ³) (Equation 5)
Naphthalene	0.00033	31	0.0198	0.059	7.50 × 10 ⁻⁶	0.00033	6.5 × 10 ⁻¹²	4.6 × 10 ⁻³	1.2 × 10 ⁻⁴	0.00063	1.4 × 10 ⁻¹⁷	3.4 × 10 ⁻¹⁰
1,4-Dichlorobenzene ^b	0.0014	31	0.23	0.088	9.80 × 10 ⁻⁶	0.0014	3.2 × 10 ⁻¹⁰	6.8 × 10 ⁻³	1.3 × 10 ⁻⁵	0.000079	8.5 × 10 ⁻¹⁷	2.1 × 10 ⁻⁹
Total DDTs ^b	0.000049	0.025	0.000332	0.0137	4.95 × 10 ⁻⁶	0.000049	1.6 × 10 ⁻¹⁴	1.2 × 10 ⁻³	4.7 × 10 ⁻³	0.00138	7.5 × 10 ⁻²⁰	1.9 × 10 ⁻¹²
1,2,4-Trimethylbenzene ^b	0.0072	31	0.0198	0.059	7.50 × 10 ⁻⁶	0.0072	1.4 × 10 ⁻¹⁰	4.6 × 10 ⁻³	1.2 × 10 ⁻⁴	0.00063	3.0 × 10 ⁻¹⁶	7.5 × 10 ⁻⁹
1,3,5-Trimethylbenzene ^b	0.003	31	0.0198	0.059	7.50 × 10 ⁻⁶	0.0030	5.9 × 10 ⁻¹¹	4.6 × 10 ⁻³	1.2 × 10 ⁻⁴	0.00063	1.2 × 10 ⁻¹⁶	3.1 × 10 ⁻⁹
Benzene	0.039	1,750	0.23	0.088	9.80 × 10 ⁻⁶	0.039	9.0 × 10 ⁻⁹	6.8 × 10 ⁻³	1.3 × 10 ⁻⁵	0.000079	2.4 × 10 ⁻¹⁵	5.9 × 10 ⁻⁸
Chlorobenzene	0.080	472	0.15	0.073	8.70 × 10 ⁻⁶	0.080	1.2 × 10 ⁻⁸	5.7 × 10 ⁻³	1.8 × 10 ⁻⁵	0.00011	4.3 × 10 ⁻¹⁵	1.1 × 10 ⁻⁷
n-Propylbenzene ^b	0.011	169	0.323	0.075	7.80 × 10 ⁻⁶	0.011	3.6 × 10 ⁻⁹	5.8 × 10 ⁻³	7.5 × 10 ⁻⁶	0.000045	5.3 × 10 ⁻¹⁶	1.3 × 10 ⁻⁸
tert-Butyl methyl ether	0.028	48,000	0.024	0.0728	8.95 × 10 ⁻⁶	0.028	6.7 × 10 ⁻¹⁰	5.7 × 10 ⁻³	1.2 × 10 ⁻⁴	0.00063	1.4 × 10 ⁻¹⁵	3.6 × 10 ⁻⁸
Vinyl chloride	0.0005	2,760	1.1	0.106	1.23 × 10 ⁻⁶	0.00050	5.5 × 10 ⁻¹⁰	8.2 × 10 ⁻³	3.6 × 10 ⁻⁷	0.0000022	4.0 × 10 ⁻¹⁸	9.9 × 10 ⁻¹¹

^a Groundwater EPCs were calculated as described in Section 3.0 of the HHRA. The values for the other model inputs were from RISC (Spence and Walden 2001) and/or from EPA (1996).

^b As a health-protective approach, structurally similar chemicals were selected as surrogates (i.e., the surrogate chemical was generally considered to be more toxic than the COPC it was representing). Benzene was used for 1,4-dichlorobenzene, 4,4'-DDT was used for total DDTs, naphthalene was used for the trimethylbenzenes, and ethylbenzene was used for n-propylbenzene.

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

EPA – US Environmental Protection Agency

EPC – exposure point concentration

HHRA – human health risk assessment

RISC – Risk-Integrated Software for Cleanup

RME – reasonable maximum exposure

Equation 6 (similar to Equation 2 presented above) calculates the initial vapor concentration at the source using Henry's Law.

$$C_{vs} = K_H C_{ws} \left(\frac{l}{1,000 \text{ cm}^3} \right) \left(\frac{g}{1,000 \text{ mg}} \right) \quad \text{Equation 6}$$

Where:

- C_{vs} = vapor concentration at the source (g/cm^3)
- K_H = COPC-specific Henry's Law constant $[(\text{mg}/\text{L vapor})/(\text{mg}/\text{L water})]$
- C_{ws} = COPC-specific dissolved-phase concentration at the source, equal to the groundwater EPC presented in Table 3 (mg/L)

Next, Equations 7a and 7b are used to calculate the effective diffusion coefficients for the vadose zone ($D_{\text{eff-v}}$) and the capillary fringe ($D_{\text{eff-cap}}$), respectively. Diffusion coefficients describe the tendency of individual molecules or ions to migrate through the vadose zone or capillary fringe.

$$D_{\text{eff-v}} = D_{\text{air}} \left(\frac{\theta_{a-v}^{10/3}}{\theta_t^2} \right) + D_{\text{water}} \frac{1}{K_H} \left(\frac{\theta_{w-v}^{10/3}}{\theta_t^2} \right) \quad \text{Equation 7a}$$

$$D_{\text{eff-cap}} = D_{\text{air}} \left(\frac{\theta_{a-cap}^{10/3}}{\theta_t^2} \right) + D_{\text{water}} \frac{1}{K_H} \left(\frac{\theta_{w-cap}^{10/3}}{\theta_t^2} \right) \quad \text{Equation 7b}$$

Where:

- $D_{\text{eff-v}}$ = effective diffusion coefficient for the vadose zone (cm^2/s)
- $D_{\text{eff-cap}}$ = effective diffusion coefficient for the capillary fringe (cm^2/s)
- D_{air} = COPC-specific molecular diffusion coefficient in air (cm^2/s)
- D_{water} = COPC-specific molecular diffusion coefficient in water (cm^2/s)
- K_H = COPC-specific Henry's Law constant $[(\text{mg}/\text{L vapor})/(\text{mg}/\text{L water})]$
- θ_t = total porosity (0.43 cm^3 of pores/ cm^3 total soil volume)
- θ_{a-v} = vadose zone air-filled porosity (0.28 cm^3 of air/ cm^3 total soil volume)
- θ_{w-v} = vadose zone water-filled porosity (0.15 cm^3 of water/ cm^3 total soil volume)
- θ_{a-cap} = capillary fringe air-filled porosity (0.005 cm^3 of air/ cm^3 total soil volume)
- θ_{w-cap} = capillary fringe water-filled porosity (0.425 cm^3 of water/ cm^3 total soil volume)

The porosity values used for the vadose zone are the same as those specified for Equation 1a. Within the capillary fringe, the air-filled porosity value used was 0.005, which is typical of many different soil types (Spence and Walden 2001). The water-filled porosity value for the capillary fringe of 0.425 was calculated as the difference between the total porosity (0.43) and the air-filled porosity value.

Using the results of Equations 7a and 7b, Equation 8 calculates the effective diffusion coefficient within groundwater, using a depth-weighted average of effective diffusion coefficients within the vadose and capillary fringe zones. Default model values provided in RISC were used for the depth of the capillary fringe (50 cm) and the depth of the vadose zone (250 cm) (Spence and Walden 2001).

$$D_{\text{eff}} = (d_{\text{cap}} + d_v) \left[\left(\frac{d_{\text{cap}}}{D_{\text{eff-cap}}} \right) + \left(\frac{d_v}{D_{\text{eff-v}}} \right) \right]^{-1} \quad \text{Equation 8}$$

Where:

- D_{eff} = effective diffusion coefficient (cm^2/s)
- d_{cap} = depth of capillary fringe (50 cm)
- d_v = depth of vadose zone (250 cm)
- $D_{\text{eff-cap}}$ = effective diffusion coefficient within capillary fringe calculated using Equation 7b (cm^2/s)
- $D_{\text{eff-v}}$ = effective diffusion coefficient within vadose zone calculated using Equation 7a (cm^2/s)

The final two steps in the process to calculate outdoor air concentrations from groundwater concentrations are the same as those used for soil. First, Equation 4 is used to calculate the volatile flux using the effective diffusion coefficient (D_{eff}) from Equation 8 and the vapor concentration at the source (C_{vs}) from Equation 6. Then, Equation 5 is used to calculate the outdoor air concentration using the vapor flux rate calculated using Equation 4.

Table 3 presents the outdoor air concentrations calculated from groundwater concentrations for the industrial (construction/trenching) worker RME scenario. These concentrations were used in the HHRA to calculate risks based on exposure to groundwater for this scenario.

3.0 References

- EPA. 1996. Soil screening guidance: User's guide. Second edition. 9355.4-23. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.
- Spence LR, Walden T. 2001. RISC 4 user's manual. Spence Engineering, Pleasant, CA.

ATTACHMENT 5 – CDI RATES, INHALATION ECs, AND DERMALLY ABSORBED DOSES FOR CONTAMINANTS OF POTENTIAL CONCERN

This attachment to the Harbor Oil baseline HHRA presents the chronic daily intake (CDI) rates and inhalation exposure concentrations (ECs) for contaminants of potential concern (COPCs) identified for the various scenarios. CDI rates represent the estimated daily COPC dose for an individual averaged over the exposure duration for each scenario and are applicable for risks via dermal absorption or ingestion. ECs represent the COPC concentrations in air used to assess risks to humans based on inhalation and are applicable to the industrial (construction/trenching) worker reasonable maximum exposure (RME) scenario. Separate CDIs and ECs were calculated for COPCs with carcinogenic and non-carcinogenic effects because the averaging times over which the doses are calculated are different. Additionally, this attachment presents the additional parameters needed to calculate the dermally absorbed dose for exposure to Force Lake surface water and groundwater in the recreational user and industrial (construction/trenching) worker scenarios, respectively.

Tables 1 through 7 of this attachment present the results of CDI, EC, and dermally absorbed dose calculations performed using Equations 3-1 through 3-9 in Section 3.3.1 and the exposure parameters given in Tables 3-8 through 3-18 of the main document. The CDI and EC results were used in the risk characterization and uncertainty analysis (Sections 5 and 6, respectively). The CDIs and ECs are expressed in scientific notation (e.g., 1.0×10^{-5} is equivalent to 0.000010). The following tables present the CDIs, ECs, and dermally absorbed doses:

- Table 1: CDIs and ECs for the Industrial (Construction/Trenching) Worker RME Scenario based on Exposure to Facility Soil
- Table 2: Dermally Absorbed Dose for the Industrial (Construction/Trenching) Worker RME Scenario based on Exposure to Groundwater
- Table 3: CDIs and ECs for the Industrial (Construction/Trenching) Worker RME Scenario based on Exposure to Groundwater
- Table 4: CDIs for the Future Outdoor Worker RME Scenario based on Exposure to Facility Soil
- Table 5: Dermally Absorbed Doses for the Recreational User RME Scenario based on Exposure to Surface Water
- Table 6: CDIs for the Force Lake Recreational User RME Scenario based on Lifetime Exposure and for Exposure to Children Ages 0 to 6
- Table 7: CDIs for the Force Lake Fish Consumer RME Scenario

In addition, the electronic data supplement to this attachment provides the data tables, ProUCL input files, and ProUCL output files to assist in the review of UCL calculations for COPCs, as used in CDI and EC calculations.

Table 1. CDIs and ECs for the Industrial (Construction/Trenching) Worker RME Scenario based on Exposure to Facility Soil

COPC	Cancer CDI (mg/kg-day)		Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)	Non-Cancer CDI (mg/kg-day)		Non-Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)
	Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	
Arsenic	3.8×10^{-7}	1.1×10^{-7}	5.1×10^{-9}	2.7×10^{-5}	8.0×10^{-6}	3.6×10^{-7}
Cobalt	6.0×10^{-7}	6.0×10^{-8}	8.0×10^{-9}	4.2×10^{-5}	na ^a	5.6×10^{-7}
Copper	na	na	na	8.7×10^{-4}	na ^a	1.2×10^{-5}
Naphthalene	9.2×10^{-8}	1.2×10^{-7}	6.1×10^{-7}	6.5×10^{-6}	8.4×10^{-6}	4.3×10^{-5}
cPAH TEQ	4.4×10^{-8}	5.7×10^{-8}	5.9×10^{-10}	na	na	na
Total PCBs	1.6×10^{-7}	2.2×10^{-7}	8.5×10^{-9}	1.1×10^{-5}	1.5×10^{-5}	6.0×10^{-7}
Total DDTs	5.1×10^{-7}	1.5×10^{-7}	6.8×10^{-9}	3.6×10^{-5}	1.1×10^{-5}	4.8×10^{-7}
1,1-Dichloroethane	3.1×10^{-8}	na ^a	1.4×10^{-4}	2.2×10^{-6}	na ^a	9.7×10^{-3}
1,2,4-Trimethylbenzene	na	na	na	1.7×10^{-5}	na ^a	1.1×10^{-4}
1,3,5-Trimethylbenzene	na	na	na	4.2×10^{-6}	na ^a	2.8×10^{-5}
Benzene	1.5×10^{-8}	na ^a	4.9×10^{-5}	1.1×10^{-6}	na ^a	3.4×10^{-3}
Chlorobenzene	na	na	na	7.1×10^{-7}	na ^a	2.7×10^{-3}
cis-1,2-Dichloroethene	na	na	na	2.8×10^{-5}	na ^a	8.6×10^{-2}
Dichloromethane	9.2×10^{-10}	na ^a	4.2×10^{-6}	6.5×10^{-8}	na ^a	3.0×10^{-4}
Ethylbenzene	8.8×10^{-8}	na ^a	na	6.1×10^{-6}	na ^a	4.5×10^{-3}
trans-1,2-Dichloroethene	na	na	na	1.8×10^{-5}	na ^a	8.0×10^{-2}
Trichloroethene	7.4×10^{-9}	na ^a	1.5×10^{-5}	na	na	na
Vinyl chloride	5.5×10^{-8}	na ^a	1.7×10^{-3}	3.9×10^{-6}	na ^a	1.2×10^{-1}
Total xylenes	na	na	na	3.2×10^{-5}	na ^a	3.0×10^{-2}
TPH-gasoline (aliphatic)	2.0×10^{-5}	na	1.5×10^{-1}	1.4×10^{-3}	na ^a	1.1×10^1

^a No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

CDI – chronic daily intake

COPC – contaminant of potential concern

cPAH – carcinogenic polyaromatic hydrocarbons

EC – exposure concentration

DDT – dichlorodiphenyltrichloroethane

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

Table 2. Dermally Absorbed Dose for the Industrial (Construction/ Trenching) Worker RME Scenario based on Exposure to Groundwater

COPC	Kp (cm/hr)	FA	t* (hrs)	B (ratio)	T (hrs)	ET (hrs/day)	DA _{event} (mg/cm ² -event)
Inorganic COPCs							
Arsenic	0.001	na	na	na	na	2	3.0×10^{-8}
Lead	0.0001	na	na	na	na	2	6.0×10^{-10}
Manganese	0.001	na	na	na	na	2	8.0×10^{-6}
Organic COPCs							
1,4-Dichlorobenzene	0.042	1.0	1.71	0.2	0.71	2	2.0×10^{-7}
Naphthalene	0.047	1.0	1.34	0.2	0.56	2	2.0×10^{-7}
Total DDTs	0.27	0.7	42.51	1.9	10.5	2	1.2×10^{-7}
1,2,4-Trimethylbenzene ^a	0.047	1.0	1.34	0.2	0.56	2	1.0×10^{-6}
1,3,5-Trimethylbenzene ^a	0.047	1.0	1.34	0.2	0.29	2	4.2×10^{-7}
Benzene	0.015	1.0	0.7	0.1	0.29	2	1.4×10^{-6}
Chlorobenzene	0.028	1.0	1.09	0.1	0.46	2	6.3×10^{-6}
n-Propylbenzene ^b	0.015	1.0	0.7	0.1	0.29	2	4.1×10^{-7}
tert-Butyl methyl ether	na	na	na	na	na	2	na
Vinyl chloride	0.0056	1.0	0.57	0	0.24	2	6.9×10^{-9}

Source: EPA RAGS Part E, Appendix B (EPA 2004).

^a Naphthalene was used as a surrogate.

^b Benzene was used as a surrogate.

B – dimensionless ratio of the permeability coefficient across the viable epidermis (ve)

COPC – contaminant of potential concern

DA_{event} – dermally absorbed dose per event

ET – exposure time

FA – fraction absorbed from water

Kp – dermal permeability coefficient of compound in water

na – not applicable or available

t* – time to reach steady state

T – lag time per event

Table 3. CDIs and ECs for the Industrial (Construction/Trenching) Worker RME Scenario based on Exposure to Groundwater

COPC	Cancer CDI (mg/kg-day)		Cancer EC for Inhalation (µg/m ³)	Non-Cancer CDI (mg/kg-day)		Non-Cancer EC for Inhalation (µg/m ³)
	Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	
Arsenic (total)	na	2.9×10^{-8}	na ^a	na	2.1×10^{-6}	na ^a
Manganese (total)	na	na	na	na	na ^b	na ^a
Naphthalene	na	1.9×10^{-7}	2.8×10^{-10}	na	1.4×10^{-5}	1.9×10^{-8}
1,4-Dichlorobenzene	na	1.9×10^{-7}	1.7×10^{-9}	na	1.4×10^{-5}	1.2×10^{-7}
Total DDTs	na	1.1×10^{-7}	1.5×10^{-12}	na	8.0×10^{-6}	1.1×10^{-10}
1,2,4-Trimethylbenzene	na	na	na	na	na ^b	4.3×10^{-7}
1,3,5-Trimethylbenzene	na	na	na	na	na ^b	1.8×10^{-7}
Benzene	na	na ^b	4.8×10^{-8}	na	na ^b	3.4×10^{-6}
Chlorobenzene	na	na	na	na	na ^b	6.3×10^{-6}
n-Propylbenzene	na	na	na	na	na ^b	7.4×10^{-7}
tert-Butyl methyl ether	na	na ^b	2.9×10^{-8}	na	na ^b	2.1×10^{-6}
Vinyl chloride	na	na ^b	8.1×10^{-11}	na	na ^b	5.7×10^{-9}

^a This COPC is not expected to volatilize significantly because of its diffusivity in air or water, and thus risks based on inhalation are not assessed here.

^b No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

EC – exposure concentration

na – not applicable

RME – reasonable maximum exposure

Table 4. CDIs for the Future Outdoor Worker RME Scenario based on Exposure to Facility Soil

COPC	Cancer CDI (mg/kg-day)		Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)	Non-Cancer CDI (mg/kg-day)		Non-Cancer EC for Inhalation ($\mu\text{g}/\text{m}^3$)
	Incidental Ingestion	Dermal Absorption		Incidental Ingestion	Dermal Absorption	
Arsenic	3.8×10^{-6}	3.8×10^{-7}	6.8×10^{-7}	1.1×10^{-5}	1.1×10^{-6}	1.9×10^{-6}
Cobalt	na	na	na	1.4×10^{-5}	na ^a	2.4×10^{-6}
Copper	na	na	na	1.5×10^{-4}	na ^a	2.6×10^{-5}
Naphthalene	na	na	na	2.5×10^{-6}	1.1×10^{-6}	2.2×10^{-4}
cPAH TEQ	3.8×10^{-7}	1.6×10^{-7}	6.8×10^{-7}	na	na	na
Total PCBs	1.8×10^{-6}	8.4×10^{-7}	1.3×10^{-6}	5.1×10^{-6}	2.4×10^{-6}	3.6×10^{-6}
Total DDTs	5.6×10^{-6}	5.5×10^{-7}	9.9×10^{-7}	1.6×10^{-5}	1.5×10^{-6}	2.8×10^{-6}
1,1-Dichloroethane	2.4×10^{-7}	na ^a	1.4×10^{-2}	6.7×10^{-7}	na ^a	3.9×10^{-2}
1,2,4-Trimethylbenzene	na	na	na	1.3×10^{-5}	na ^a	1.1×10^{-3}
1,3,5-Trimethylbenzene	na	na	na	2.9×10^{-6}	na ^a	2.5×10^{-4}
Benzene	1.8×10^{-7}	na ^a	7.6×10^{-3}	5.0×10^{-7}	na ^a	2.1×10^{-2}
cis-1,2-Dichloroethene	na	na	na	1.3×10^{-4}	na ^a	$5.0 \times 10^{+0}$
Dichloromethane	1.6×10^{-8}	na ^a	9.8×10^{-4}	4.6×10^{-8}	na ^a	2.7×10^{-3}
Ethylbenzene	1.1×10^{-6}	na ^a	1.1×10^{-2}	3.0×10^{-6}	na ^a	3.0×10^{-2}
trans-1,2-Dichloroethene	na	na	na	5.4×10^{-6}	na ^a	3.2×10^{-1}
Trichloroethene	9.4×10^{-8}	na ^a	2.5×10^{-3}	na	na	na
Vinyl chloride	4.2×10^{-7}	na ^a	1.7×10^{-1}	1.2×10^{-6}	na ^a	4.8×10^{-1}
Total xylenes	na	na	na	1.6×10^{-5}	na ^a	1.9×10^{-1}
TPH-gasoline (aliphatic)	2.3×10^{-4}	na ^a	1.5×10^1	6.5×10^{-4}	na ^a	4.3×10^1

^a No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

CDI – chronic daily intake

COPC – contaminant of potential concern

cPAH – carcinogenic polyaromatic hydrocarbons

DDT – dichlorodiphenyltrichloroethane

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

Table 5. Dermal Absorbed Doses for the Recreational User RME Scenario based on Exposure to Surface Water

COPC	Age Group	Kp (cm/hr)	ET (hrs/day)	DA _{event} (mg/cm ² -event)
Arsenic (total)	child (aged 0 to 6)	0.001	1.7	2.0×10^{-9}
Arsenic (total)	older child (aged 7 to 16)	0.002	2.35	2.8×10^{-9}
Arsenic (total)	Adult (aged 17 to 30)	0.002	3.3	4.0×10^{-9}

Source: EPA RAGS Part E, Appendix B (EPA 2004).

COPC – contaminant of potential concern

DA_{event} – dermally absorbed dose per event

ET – exposure time

Kp – dermal permeability coefficient of compound in water

Table 6. CDIs for the Force Lake Recreational User RME Scenario based on Lifetime Exposure and for Exposure to Children Ages 0 to 6

COPC	Lifetime Exposure (aged 0 to 30)				Children (aged 0 to 6)	
	Cancer CDI (mg/kg-day)		Non-Cancer CDI (mg/kg-day)		Non-Cancer CDI (mg/kg-day)	
	Incidental Ingestion	Dermal Absorption	Incidental Ingestion	Dermal Absorption	Incidental Ingestion	Dermal Absorption
Wetland Soil						
Aluminum	na	na	3.7×10^{-3}	na ^a	1.1×10^{-2}	na ^a
Antimony	na	na	3.4×10^{-7}	na ^a	9.9×10^{-7}	na ^a
Arsenic	1.3×10^{-6}	1.5×10^{-7}	3.0×10^{-6}	3.6×10^{-7}	8.6×10^{-6}	5.2×10^{-7}
Chromium	na	na	1.1×10^{-5}	na ^a	3.3×10^{-5}	na ^a
Cobalt	na	na	3.7×10^{-6}	na ^a	1.1×10^{-5}	na ^a
Copper	na	na	5.0×10^{-5}	na ^a	1.4×10^{-4}	na ^a
Iron	na	na	1.8×10^{-2}	na ^a	5.1×10^{-2}	na ^a
Manganese	na	na	3.4×10^{-4}	na ^a	9.9×10^{-4}	na ^a
Vanadium	na	na	2.4×10^{-5}	na ^a	6.8×10^{-5}	na ^a
Naphthalene	na	na	2.0×10^{-7}	1.0×10^{-7}	5.7×10^{-7}	1.5×10^{-7}
cPAH TEQ	1.5×10^{-7}	7.7×10^{-8}	na	na	na	na
Total PCBs	1.0×10^{-7}	5.8×10^{-8}	2.4×10^{-7}	1.3×10^{-7}	6.9×10^{-7}	1.9×10^{-7}
Total DDTs	1.2×10^{-6}	1.5×10^{-7}	2.8×10^{-6}	3.4×10^{-7}	8.2×10^{-6}	4.9×10^{-7}
Benzene	1.0×10^{-9}	na ^a	2.4×10^{-9}	na ^a	6.9×10^{-9}	na ^a
Trichloroethene	1.0×10^{-9}	na ^a	na	na	na	na
TPH-gasoline (aliphatic)	na	na	7.8×10^{-6}	na ^a	2.2×10^{-5}	na ^a
TPH-diesel (aliphatic)	na	na	2.4×10^{-4}	na ^a	7.0×10^{-4}	na ^a
Lake Sediment						
Arsenic	8.5×10^{-7}	1.0×10^{-7}	2.0×10^{-6}	2.4×10^{-7}	5.7×10^{-6}	3.4×10^{-7}
Chromium	na	na	9.3×10^{-6}	na ^a	2.7×10^{-5}	na ^a
Cobalt	na	na	4.3×10^{-6}	na ^a	1.3×10^{-5}	na ^a
Vanadium	na	na	2.1×10^{-5}	na ^a	6.0×10^{-5}	na ^a
cPAH TEQ	1.1×10^{-8}	5.6×10^{-9}	na	na	na	na
TPH-gasoline (aliphatic)	na	na	1.1×10^{-5}	na ^a	3.1×10^{-5}	na ^a
Lake Surface Water						
Arsenic (total)	9.3×10^{-8}	8.1×10^{-9}	2.2×10^{-7}	1.9×10^{-8}	4.6×10^{-7}	1.8×10^{-8}

^a No dermal absorption factor is available for this COPC. Dermal exposure for this COPC is discussed in the uncertainty analysis (Section 6.0).

CDI – chronic daily intake

COPC – contaminant of potential concern

cPAH – carcinogenic polyaromatic hydrocarbons

DDT – dichlorodiphenyltrichloroethane

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

Table 7. CDIs for the Force Lake Fish Consumer RME Scenario

COPC	Fish Tissue Consumption CDIs (mg/kg-day)		
	Lifetime Exposure		Child (age 0 to 6)
	Cancer CDI	Non-Cancer CDI	Non-Cancer CDI
Arsenic	5.0×10^{-6}	1.2×10^{-5}	1.7×10^{-5}
Barium	na	3.0×10^{-3}	4.5×10^{-3}
Cadmium	na	2.3×10^{-5}	3.4×10^{-5}
Cobalt	na	2.1×10^{-4}	3.1×10^{-4}
Copper	na	1.2×10^{-3}	1.7×10^{-3}
Mercury	na	1.1×10^{-6}	1.6×10^{-6}
Nickel	na	4.1×10^{-4}	6.0×10^{-4}
Vanadium	na	1.0×10^{-3}	1.5×10^{-3}
Zinc	na	5.3×10^{-3}	7.8×10^{-3}
Total PCBs	7.5×10^{-6}	1.7×10^{-5}	2.6×10^{-5}
Total DDTs	6.8×10^{-6}	1.6×10^{-5}	2.3×10^{-5}

CDI – chronic daily intake

COPC – contaminant of potential concern

DDT – dichlorodiphenyltrichloroethane

na – not applicable

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

References

EPA. 2004. Risk assessment guidance for Superfund: volume 1—Human health evaluation manual (Part E, supplemental guidance for dermal risk assessment). Final, July 2004. EPA/540/R/99/005. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

ATTACHMENT 6 – TOXICOLOGICAL PROFILES FOR CONTAMINANTS OF POTENTIAL CONCERN

The following sections provide toxicological information for each of the contaminants that were identified as COPCs in this human health risk assessment (HHRA). The toxicity values used in this risk assessment are in bold type. Toxicity information was obtained primarily from:

- US Environmental Protection Agency (EPA's) Integrated Risk Information System (IRIS) (EPA 2006b)
- EPA's 1997 Health Effects Summary Tables (HEAST) (EPA 1997b)
- Toxicological profiles presented in *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* (EPA 2000)
- EPA's Office of Ground Water and Drinking Water (OGWDW) (EPA 2006)
- Agency for Toxic Substance and Disease Registry (ATSDR; 2006e)
- ToxFAQs (ATSDR 2006a)
- Hazardous Substance Data Bank (HSDB) (TOXNET 2006)

Since quantitative estimates of toxicity potential have been developed by EPA and other agencies, it is necessary to establish a hierarchy to determine which toxicity values should be used. EPA (2003) has developed a hierarchical order of toxicity values for use in HHRAs:

- Tier 1 – EPA's IRIS
- Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), Office of Research and Development/National Center for Environmental Assessment
- Tier 3 – Other toxicity values. Tier 3 includes additional EPA and non-EPA sources of toxicity information. Priority is given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed. Sources include EPA Regional offices, EPA HEAST values, Cal/EPA, and ATSDR minimal risk levels (MRLs)

Online versions of IRIS, HSDB, and ToxFAQs are cited by acronym only in the sections below. These databases were accessed between February and April 2006. Other citations are presented in standard form. The carcinogenic evaluation of chemicals by the International Agency for Research on Cancer (IARC) and toxicity evaluations by the National Center for Environmental Assessment (NCEA, a division of EPA), as cited in other documents, are also referred to by their acronyms.

Toxicological Profiles

Toxicological profiles for COPCs identified in this HHRA are provided in this section. These profiles include information concerning the COPC's pharmacokinetics, acute toxicity, chronic toxicity, and carcinogenicity.

1. 1,1-Dichloroethane

1,1-Dichloroethane is manufactured and does not exist naturally in the environment. 1,1-Dichloroethane was formerly used as a surgical anesthetic but is not currently used for this purpose (ATSDR 1990a). 1,1-Dichloroethane is currently used in the fabrication of other chemicals and to dissolve substances such as paint, varnish, and finish removers. It is also used to remove grease (ATSDR 1990a).

Acute Toxicity

There is very little information on the acute effects of 1,1-dichloroethane but during use as a surgical anesthetic, effects on the heart were reported, such as irregular heartbeats (ATSDR 1990a).

Chronic Toxicity

1,1-Dichloroethane has been found to cause kidney disease in animals after long-term exposure to elevated levels in the air. Delayed growth was also observed in the offspring of animals who were exposed to 1,1-dichloroethane in the air during pregnancy (ATSDR 1990a). EPA's PPRTV provides an **RfD for 1,1-dichloroethane of 0.2 mg/kg-day**. RAIS provides an inhalation **RfC for 1,1-dichloroethane of 0.5 mg/m³**.

Carcinogenicity

1,1-Dichloroethane has been found to cause cancer in rats and mice when fed large doses throughout their lifetime (ATSDR 1990a). EPA's IRIS has classified 1,1-dichloroethane as a possible (Group C) human carcinogen. California EPA has established an **oral cancer slope of 0.0057 kg/mg-day⁻¹** and an **inhalation unit risk of 1.60E-06 (µg/m³)⁻¹**.

2. 1,2,4-Trimethylbenzene and 1,3,5-Trimethylbenzene

Acute Toxicity

Exposure to 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene can cause irritation of the eyes, skin, and respiratory tract; and can cause effects on the central nervous system. Ingestion of 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene can cause chemical pneumonitis (NIOSH 2004, 2005).

Chronic Toxicity

Long term exposure to 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene may result in chronic bronchitis and may have effects on the central nervous system and blood (NIOSH 2004, 2005).

EPA's PPRTV provides an **RfD for 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene of 0.05 mg/kg-day**.

EPA's PPRTV provides an **RfC for 1,3,5-trimethylbenzene of 0.006 mg/m³**. IRIS provides an **RfC for 1,2,4-trimethylbenzene of 0.007 mg/m³**.

Carcinogenicity

The carcinogenicity of 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene is not well documented. RAIS has identified 1,3,5-trimethylbenzene as not classifiable as to human carcinogenicity (Group D).

3. 1,4-Dichlorobenzene

1,4-Dichlorobenzene is currently used as a restroom or garbage deodorant and for moth control. It has also been used as an insecticide on fruits and as a method of control for mold and mildew on tobacco seeds, leather and fabrics. 1,4-Dichlorobenzene has a strong odor of moth-balls and typically sublimates at room temperatures. 1,4-Dichlorobenzene is also an important component in the fabrication of resins (ATSDR 2006b).

Acute Toxicity

Inhaling 1,4-dichlorobenzene at very high concentrations can cause irritation to and burning in the eyes and nose. Inhalation may also cause tearing of the eyes, coughing, difficult breathing, and an upset stomach. One study reported a decrease in lung function after inhalation. High levels of 1,4-dichlorobenzene have also been reported to cause dizziness, headaches, and liver problems. Inhalation or ingestion of 1,4-dichlorobenzene has been found to cause liver problems in test animals (ATSDR 2006b).

Chronic Toxicity

Inhalation or ingesting 1,4-dichlorobenzene over a lifetime has been found to cause liver cancer in mice. Humans who ingested 1,4-dichlorobenzene regularly over time were found to develop skin blotches and problems with red blood cells such as anemia (ATSDR 2006b). ATSDR provides an **RfD for 1,4-dichlorobenzene of 0.07 mg/kg-day**. EPA's IRIS provides an **RfC of 0.8 mg/m³**.

Carcinogenicity

1,4-Dichlorobenzene has been found to cause liver cancer in test animals when ingested (ATSDR 2006b). RAIS classifies 1,4-dichlorobenzene as a possible (Group C) human carcinogen. California EPA has established an **oral cancer slope factor of 5.40E-03 kg/mg-day⁻¹** and an **inhalation unit risk of 0.00001 (µg/m³)⁻¹**.

4. Aluminum

Aluminum is the most abundant metal and the third most abundant element, after oxygen and silicon, in the earth's crust. It is widely distributed and constitutes approximately 8% of the earth's surface layer. However, aluminum is a very reactive element and is never found as free metal in nature. It is found combined with other elements, most commonly with oxygen, silicon, and fluorine. High concentrations in the environment can be caused by the mining and processing of its ores and by the production of aluminum metal, alloys, and compounds. Small amounts of aluminum are released into the environment from coal-fired power plants and incinerators (ATSDR 1999a).

Acute Toxicity

Low-level exposure to aluminum from food, air, water, or contact with skin is not thought to harm your health (ATSDR 1999a). Aluminum, however, is not a necessary substance for our bodies and too much may be harmful. People who are exposed to high levels of aluminum in air may have respiratory problems including coughing and asthma from breathing dust.

Chronic Toxicity

Some studies show that people with Alzheimer's disease have more aluminum than usual in their brains. Data are inconclusive on whether aluminum causes the disease or whether the buildup of aluminum happens to people who already have the disease. Aluminum is known to cause additional neurological problems such as memory loss and impaired motor skills. Infants and adults who received large doses of aluminum as a treatment for another problem developed bone diseases, which suggests that aluminum may cause skeletal problems. Some sensitive people develop skin rashes from using aluminum chlorohydrate deodorants (ATSDR 1999a). EPA's PPRTV provides an **RfD for aluminum of 1 mg/kg-day** (EPA 2004).

Carcinogenicity

EPA has not conducted a complete evaluation and determination of the carcinogenicity of aluminum (IRIS). Available data suggest that this element is not carcinogenic (ATSDR 1999a). RAIS has identified aluminum as not classifiable as to human carcinogenicity (Group D).

5. Antimony

Antimony is naturally present in the earth's crust. The release of antimony into the environment occurs primarily through anthropogenic sources such as non-ferrous metal mining, smelting, refining, and production, the use and disposal of antimony alloys and compounds, coal combustion, and refuse and sludge combustion. Antimony exposure occurs through inhalation, ingestion of food containing antimony, and through dermal contact (IRIS).

Acute Toxicity

Violent vomiting, diarrhea, lowered respiratory rate, myocardial edema, hyperemia, and capillary engorgement are major results of acute exposure to antimony. Seventy people became acutely ill after ingesting lemonade containing 0.013% antimony. Fifty-six of the victims were treated for burning stomach pains, colic, nausea, and vomiting. Most recovered after approximately three hours, while some required hospitalization for a few days (IRIS).

Chronic Toxicity

Dyspnea, weight and hair loss, popular eruptions on the skin, jaundice, damage to the heart and liver, and spleen, kidney damage, abnormal increase in erythrocytes, and a decrease in leukocytes are reported from long-term exposure to antimony. Chronic inhalation results in damage to the lungs, liver and heart (HSDB). EPA developed an **RfD for antimony of 0.0004 mg/kg-day** based on a study in which rats were exposed to potassium antimony tartrate hemi.

Carcinogenicity

EPA has not conducted a complete evaluation and determination of the carcinogenicity of antimony (IRIS).

6. Arsenic

Arsenic is a naturally occurring element in the earth's crust that is usually found combined with other elements. Arsenic combined with elements such as oxygen, chlorine, and sulfur is referred to as inorganic arsenic; arsenic combined with carbon and hydrogen is referred to as organic arsenic. Arsenic in seafood is more commonly in the organic form (EPA 1997a). Most of the common organic forms, such as arsenobetaine and arsenocholine, are non-toxic, but other forms that may also occur to some extent, such as dimethylated and monomethylated arsenic acids, are more toxic (EPA 1997a). Some seafood may also contain arseno-sugars, which may be metabolized to dimethyl arsenic (ICF Kaiser 1996).

Acute Toxicity

Arsenicals have been recognized as a human poison since ancient times, and large doses, approximately 600 µg/kg-day or higher, taken orally have resulted in death (EPA 2000). Oral exposure to lower levels of arsenic has resulted in effects on the gastrointestinal system (nausea, vomiting); central nervous system (headaches, weakness, delirium); cardiovascular system (hypotension, shock); and the liver, kidney, and blood (anemia, leucopenia). Because significant information is available on the acute effects of arsenic poisoning in humans, few animal studies have been carried out. The limited available data have shown arsenic to have low to moderate acute toxicity to animals, based on LD50s between 50 and 5,000 mg/kg (ATSDR 2005a).

Chronic Toxicity

The primary effects noted in humans from chronic exposure to arsenic are effects on the skin. Oral exposure has resulted in a pattern of skin changes that include the formations of warts or corns on the palms and soles, along with areas of darkened skin on the face, neck, and back (EPA 2000). Blackfoot disease, a disease characterized by a progressive loss of circulation in the hands and feet, leading ultimately to necrosis and gangrene, is associated with arsenic (ATSDR 2005a). Other effects noted from chronic oral exposure include peripheral neuropathy, cardiovascular disorders, and liver and kidney disorders.

EPA's IRIS database provides an **RfD for inorganic arsenic of 0.0003 mg/kg-day**, based on a no observed adverse effects level (NOAEL) (adjusted to include arsenic exposure from food) of 0.0008 mg/kg-day. The RfD was based on two studies that showed that the prevalence of blackfoot disease increased with both age and dose for individuals exposed to high levels of arsenic in drinking water. California EPA also provides an **RfC of 0.000015 mg/m³**.

Carcinogenicity

There is clear evidence that chronic exposure of humans to inorganic arsenic increases the risk of cancer. Ingestion of arsenic has been associated with an increased risk of non-melanoma skin cancer, and bladder, liver, and lung cancer. In addition, studies have reported that inhalation of arsenic results in an increased risk of lung cancer (EPA 2000). Dimethyl arsenic may be a promoter of

various forms of cancer in rats and mice (Kenyon and Hughes 2001). EPA has classified inorganic arsenic in Group A—Known Human Carcinogen, based on the increased incidence in humans of lung cancer through inhalation exposure and the increased risk of skin, bladder, liver, and lung cancer through drinking water exposure.

The **oral cancer slope factor for arsenic is 1.5 mg/kg-day⁻¹** (IRIS). EPA used data from Taiwan concerning skin cancer incidence, age, and level of exposure via drinking water. In 37 villages that had obtained drinking water for 45 years from artesian wells with various elevated levels of arsenic, 40,421 individuals were examined for hyperpigmentation, keratosis, skin cancer, and blackfoot disease. The local well waters were analyzed for arsenic, and the age-specific cancer prevalence rates were correlated with both local arsenic concentrations and duration of exposure. **EPAs IRIS database also identifies an inhalation unit risk of 0.0043 (μg/m³)⁻¹.**

7. Barium

Barium metal does not occur in nature. The most common barium ores are sulfate, barite, carbonate, and witherite. The largest use of barium is in the removal of traces of gases from vacuum and television picture tubes. Barium is released into the environment through the disposal of drilling waste, copper smelting, manufacture of motor vehicle parts, combustion of coal and oil, and the mining, refining, and production of barium and barium-based chemicals (OGWDW).

Acute Toxicity

Exposure to large quantities of barium can cause gastrointestinal disturbances and muscular weakness. No Health Advisories have been established for short-term exposure to barium (OGWDW).

Chronic Toxicity

Chronic exposure to barium can cause hypertension (ODWDW). Populations with pulmonary diseases are especially at risk. Barium is not considered an industrial health hazard (HSDB). EPA has established an oral **RfD for barium of 0.2 mg/kg-day (IRIS).**

Carcinogenicity

No suitable bioassays or epidemiological studies are available to assess the carcinogenicity of barium (IRIS). EPA has placed barium in weight-of-evidence group D, not classifiable as to human carcinogenicity.

8. Benzene

Benzene is widely used in the United States and can be made from natural processed or as a result of human activity. Benzene is used to make lubricants, dyes, detergents, drugs, pesticides, rubbers, plastics, resins, nylon, and other synthetic fibers. Benzene is found in emissions from volcanoes and forest fires. It is also found in crude oil, gasoline, and cigarette smoke.

Acute Toxicity

Inhalation of benzene can cause drowsiness, dizziness, and unconsciousness. Inhalation of high volumes can cause death, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Ingestion can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate and death (ATSDR 2007b).

Chronic Toxicity

Long term exposure to benzene has been found to cause effects on the bone marrow and anemia and leukemia. Benzene can reduce the amount of red blood cells and can cause excessive bleeding. Benzene can also affect the immune system. Women who inhaled benzene over time were found to have irregular menstrual periods and a decrease in ovary size, although it is not certain that benzene was the cause of the effects (ATSDR 2007b). EPA's IRIS database provides an **RfD for benzene of 0.004 mg/kg-day and an RfC of 0.03 mg/m³**.

Carcinogenicity

Long term exposure has been found to cause acute myelogenous leukemia, a cancer of the blood-forming organs (ATSDR 2007b). EPA has classified benzene as a human carcinogen (Class A). EPA's IRIS database provides an **oral cancer slope factor of 0.055 kg/mg-day⁻¹ and an inhalation unit risk of 7.80E-06 (µg/m³)⁻¹**.

9. Cadmium

Cadmium is a heavy metal that is released through a wide variety of industrial and agricultural activities. The accumulation of cadmium in human and other biological tissue has been evaluated in both epidemiological and toxicological studies. ATSDR (1999b) has determined that exposure conditions of most concern are long-term exposure to elevated levels in the diet.

Acute Toxicity

Effects of acute oral exposure to cadmium include gastrointestinal irritation, nausea, vomiting, abdominal pain, cramps, salivation, and diarrhea. Lethal doses in humans caused massive fluid loss, edema, and widespread organ destruction. The ingested doses were 25 and 1,500 mg/kg (ATSDR 1999b; FDA 1993).

Chronic Toxicity

Kidney toxicity is the main concern with cadmium exposure, with the critical effect being significant proteinuria (an indicator of kidney toxicity). The **RfD for cadmium in food was calculated to be 0.001 mg/kg-day** (IRIS). The RfD was calculated using a toxicokinetic model to determine the highest level of cadmium in the human renal cortex not associated with significant proteinuria (EPA 2000).

Cadmium causes many other types of toxic effects in addition to kidney toxicity, such as reducing the gastrointestinal uptake of iron, bone disorders, and increased calcium excretion. Some human studies have shown cardiovascular toxicity and elevated blood pressure, but the results are conflicting (ATSDR 1999b). In addition, animal studies indicate that cadmium causes a wide variety of alterations in the function of the immune system.

Carcinogenicity

No animal or human oral exposure studies suggest that cadmium is carcinogenic via the oral exposure route, although cadmium is classified as a probable human carcinogen (B1) by EPA based on inhalation studies in humans (EPA 2000). ATSDR has concluded that there is minimal evidence of an association between cadmium exposure and increased cancer risk in humans but that the statistical power of the studies examined to detect an effect was not high. They determined that neither the human nor the animal studies provided enough evidence to agree on the carcinogenic status of cadmium by the oral route (ATSDR 1999b).

10. cPAH TEQ

PAHs are a group of organic chemicals that have a fused ring structure of two or more benzene rings, and are formed during the incomplete combustion of organic materials. Industrial activities which produce PAHs include: coal coking, production of carbon blacks, creosote, coal tar, petroleum refining, synfuel production from coal, and the use of Soderberg electrodes in aluminum smelters and ferrosilicum and iron works (EPA 2000). Domestic activities which produce PAHs include: cigarette smoke, burning of wood and fossil fuels, waste incineration, broiling and smoking foods, and the use of combustion engines. Benzo(a)pyrene is the PAH with the most available health effects data.

Acute Toxicity

There are little data describing acute toxicity of PAHs after inhalation, oral, or dermal exposure in humans or animals. However, benzo(a)pyrene is fatal to mice following ingestion, and the liver and the skin have been identified as target organs in animals after oral or dermal exposure, respectively (ATSDR 1995). The intraperitoneal LD50 values (injected dose which kills ½ of the animals being tested) in mice for pyrene, anthracene, and benzo(a)pyrene are 514, >430, and 232 mg/kg, respectively.

Chronic Toxicity

PAHs have a high chronic exposure toxicity characterized by chronic dermatitis and hyperkeratosis (ATSDR 1995). Chronic studies in animals exposed to PAHs via ingestion, intratracheal installation, or skin-painting have not as yet identified adverse health effects other than cancer. RfDs have not been developed for any of the carcinogenic PAHs being evaluated in this Phase 1 HHRA.

Carcinogenicity

Occupational studies of workers exposed to mixtures containing PAHs have shown that mixtures of PAHs are carcinogenic to humans. Cancer associated with exposure to PAH containing mixtures in humans occurs mainly in the lung and skin following inhalation and dermal exposure.

The EPA and California EPA describe the cancer causing ability of individual cPAHs relative to the cancer causing ability of a reference compound, benzo(a)pyrene (EPA 1993; California EPA 1994). This approach is described in greater detail in Sections B.2.2 and B.4 of the risk assessment. The oral cancer slope factor developed by EPA for carcinogenicity of benzo(a)pyrene is **7.3 mg/kg-day⁻¹** (IRIS). EPA has classified benzo(a)pyrene as a probable human carcinogen (B2) based on observations of significant dose-related increases in

multiple studies of rats and mice of both sexes (IRIS). The oral cancer potency factor was applied to the sum of cPAHs, using the PEFs described in Section B.2.2.

11. Chlorobenzene

Chlorobenzene is manufactured and does not exist naturally in the environment. Production of chlorobenzene reached its peak in 1960 and has declined by more than half. Chlorobenzene was used in the fabrication of other chemicals such as phenol and DDT. It is currently used as solvent for pesticides, as a degreaser and is used to make other chemicals (ATSDR 1990b).

Acute Toxicity

Inhalation of high levels of chlorobenzene may cause headaches, nausea, sleepiness, numbness, and vomiting. It is not certain that chlorobenzene is the cause of these symptoms because the study involved workers who may have been exposed to other chemicals at the same time. Animal studies have found that chlorobenzene affects the liver, kidney, and the central nervous system. Inhalation can cause unconsciousness, tremors, restlessness, and death (ATSDR 1990b).

Chronic Toxicity

Exposure over time to chlorobenzene has been found to cause liver and kidney damage (ATSDR 1990b). EPA's IRIS database provides an **RfD for chlorobenzene of 0.02 mg/kg-day** and EPA's PPRTV database provides an **RfC of 0.05 mg/m³**.

Carcinogenicity

Chlorobenzene has been found to cause the production of liver nodules in male rats which can lead to cancer. It is not known whether chlorobenzene causes cancer in humans (ATSDR 1990b). EPA's IRIS database identifies chlorobenzene as not classifiable as to human carcinogenicity (Group D).

12. Chromium

Trivalent chromium is naturally occurring with low toxicity. Hexavalent chromium, however, is released into the environment through industrial emissions and is highly toxic due to its strong oxidation characteristics and membrane permeability. Hexavalent chromium is used in chromate manufacturing, ferrochromium industries, and in metal alloys (HSDB). Because there is no evidence to suggest that hexavalent chromium is present at the Study Area, toxicity values used in this HHRA are based on trivalent chromium.

Acute Toxicity

The acute toxic effects of hexavalent chromium were studied in 1965 when 155 people were exposed to 20 mg/L hexavalent chromium in their drinking water. The victims suffered from mouth sores, diarrhea, stomachaches, indigestion, vomiting, increased white blood cell counts, and a higher per capita cancer rate. Acute exposure to hexavalent chromium may also affect fetal development. Dermal exposure to hexavalent chromium can cause skin irritation and allergic contact dermatitis (IRIS).

Chronic Toxicity

Chronic exposure to chromium can cause damage to the liver, kidney, and circulatory system, as well as cause nerve tissue damage and dermatitis (OGWDW). **EPA has developed RfDs of 1.5 and 0.003 mg/kg-day for trivalent and hexavalent chromium, respectively (IRIS).** The RfD for trivalent chromium will be applied to all chromium data in this HHRA as discussed above.

Carcinogenicity

EPA has classified trivalent chromium as Group D, not classifiable as to human carcinogenicity. Hexavalent chromium is a Group A known human carcinogen via the inhalation pathway (IRIS).

13. cis-1,2-Dichloroethene and trans-1,2-Dichloroethene

1,2- Dichloroethene has two isomers; *cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene. 1,2- Dichloroethene is currently used to produce solvents and is also used in chemical mixtures (ATSDR 1996a).

Acute Toxicity

Inhalation of 1,2- dichloroethene can cause nausea, drowsiness, fatigue and death. Animal studies found that inhalation of high levels of *trans*-1,2-dichloroethene caused liver and lung damage. Inhalation of very high levels caused heart damage in animals. Ingestion of high levels of 1,2- Dichloroethene caused death in animals. Lower levels of *cis*-1,2-dichloroethene caused a decrease in the count of red blood cells and had effects on the live (ATSDR 1996a).

Chronic Toxicity

There is limited information on the long term effects of exposure to 1,2-dichloroethene. One animal study found that exposure may cause a decrease in fetus growth. EPA's PPRTV database provides an **RfD for cis-1,2-dichloroethene of 0.01 mg/kg-day**. EPA's IRIS database provides an **RfD for trans-1,2-dichloroethene of 0.02 mg/kg-day**. EPA's PPRTV database provides an **RfC for trans-1,2-dichloroethene of 0.06 mg/m³**.

Carcinogenicity

EPA's IRIS database has identified cis-1,2-dichloroethene as not classifiable as to human carcinogenicity (Group D).

14. Cobalt

Cobalt occurs naturally in elemental form and is found in rocks, soil, water, plants, and animals. Cobalt is part of vitamin B12, which is beneficial to humans. Cobalt is currently used to produce alloys which are used to manufacture aircraft engines, magnets, grinding and cutting tools, artificial hip and knee joints. Cobalt can also be used to add color to glass, ceramics and paints, and is also used as a drier for porcelain enamel and paints. Radioactive cobalt is used to sterilize medical equipment and other products, radiation therapy for treating cancer patients, manufacturing plastics, irradiating food and in medical and scientific research (ATSDR 2004a).

Acute Toxicity

Cobalt has been found to affect the lungs and heart and can cause dermatitis. Cobalt affected the liver and kidneys of animals exposed to high levels of cobalt. Radioactive cobalt can cause cell damage if exposed to high levels. Radioactive cobalt can also cause nausea, vomiting, diarrhea, bleeding, coma, and even death but these symptoms are not common (ATSDR 2004a).

Chronic Toxicity

The chronic toxicity of cobalt is not well documented. EPA's PPRTV provides an **RfD for cobalt of 0.0003 mg/kg-day and an RfC of 6.0E-6 mg/m³**.

Carcinogenicity

Cobalt has been found to cause cancer in animals that inhaled cobalt and in animals that had cobalt placed in the muscle or under the skin. Ingestion of cobalt has not been linked to cancer. High levels of radioactive cobalt has been found to alter the genetic material in cells and could result in cancer (ATSDR 2004a). RAIS classifies cobalt as a probable (Group B1) human carcinogen.

15. Copper

Copper occurs naturally in elemental form and as a component of many minerals. Because of its high electrical and thermal conductivity, it is widely used in the manufacture of electrical equipment. Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (Faust 1992). Copper can be absorbed by the oral, inhalation, and dermal routes of exposure.

Acute Toxicity

In humans, ingestion of gram quantities of copper salts may cause gastrointestinal, hepatic, and renal effects with symptoms such as severe abdominal pain, vomiting, diarrhea, hemolysis, hepatic necrosis, hematuria, proteinuria, hypotension, tachycardia, convulsions, coma, and death (Faust 1992). Acute inhalation exposure to copper dust or fumes at concentrations of 0.075 to 0.12 mg Cu/m³ may cause metal fume fever with symptoms such as cough, chills, and muscle ache (Faust 1992). Among the reported effects in workers exposed to copper dust are gastrointestinal disturbances, headache, vertigo, drowsiness, and increase in liver size.

Chronic Toxicity

Gastrointestinal disturbances and liver toxicity have resulted from long-term exposure to drinking water containing 2.2 to 7.8 mg Cu/L (Faust 1992). The chronic toxicity of copper has been characterized in patients with Wilson's disease, a genetic disorder causing copper accumulation in tissues. Vineyard workers chronically exposed to Bordeaux mixture (copper sulfate and lime) exhibit degenerative changes of the lungs and liver. Dermal exposure to copper may cause contact dermatitis in some individuals (ATSDR 2004b). Additionally, high levels of copper are known to cause kidney and liver damage (ATSDR 2004b).

EPA has not developed an oral RfD for elemental copper. EPA's HEAST proposed a provisional value of **0.04 mg/kg-day** (EPA 2005). Provisional RfDs have greater uncertainty than RfDs certified by EPA.

Carcinogenicity

No suitable bioassays or epidemiological studies are available to assess the carcinogenicity of copper (Faust 1992). EPA has placed copper in weight-of-evidence group D, not classifiable as to human carcinogenicity.

16. DDTs

DDT is an organochlorine pesticide that has not been marketed in the United States since 1972 but is ubiquitous due to its widespread use in previous decades and its relatively long half-life. DDT's close structural analogs, DDE and DDD, are metabolites of DDT and have also been formulated as pesticides in the past (EPA 2000). DDT is very widely distributed; it has been found in wildlife all over the world and in many human samples as well.

Although some use of DDT continues throughout the tropics, it remains of human health concern in the United States primarily due to its presence in water, soil, and food. Because individuals are typically exposed to a mixture of DDE, DDT, and DDD and their degradation and metabolic products, the sum of the 4,4' and 2,4' isomers of DDT, DDE, and DDD will be evaluated together in this HHRA.

Acute Toxicity

The low effect dose for severe effects (acute pulmonary edema) in infants has been reported to be 150 mg/kg. In adults, behavioral effects were noted at 5 to 6 mg/kg and seizures at 16 mg/kg (HSDB). Evidence from acute exposure studies of dogs indicates that DDT may sensitize the myocardium to epinephrine. This was observed for both injected epinephrine and epinephrine released by the adrenal glands during a seizure and resulted in ventricular fibrillation. DDT may concurrently act on the CNS, in a manner similar to that of other halogenated hydrocarbons, to increase the likelihood of fibrillation. Chronic exposure to 10 mg/kg-day did not produce increased incidence of arrhythmias in rats or rabbits (EPA 2000).

DDD is considered less toxic than DDT in animals. Symptoms develop more slowly and have a longer duration with DDD than with DDT exposure. Lethargy is more significant and convulsions are less common than with DDT exposure (HSDB).

Chronic Toxicity

Extensive research has been conducted on chronic and sub-chronic exposure effects of DDT in animals and in humans working with DDT. These studies have primarily focused on carcinogenic effects, which are discussed in the following section. Studies have also identified liver damage, and there is limited evidence that DDT may cause an increase in the number of white blood cells and decreased hemoglobin level (EPA 2000). Immunological effects have been associated with exposure to DDT.

IRIS lists an **oral RfD of 0.0005 mg/kg-day** for DDT based on liver effects with a NOAEL of 0.05 mg/kg-day from a 27-week rat feeding study conducted in 1950 (IRIS).

Carcinogenicity

DDE, DDT, and DDD are all considered probable human carcinogens (category B2) based on animal studies, with **oral cancer slope factors of 0.24, 0.34, and 0.34 per mg/kg-day⁻¹**, respectively (IRIS). Liver tumors were associated with each chemical. The occupational studies of workers exposed to DDT are of insufficient duration to assess carcinogenicity (IRIS). Elevated leukemia incidence, particularly chronic lymphocytic leukemia, was noted in two studies of workers. Lung cancer has also been implicated in one study. Bone marrow cells in experimental animals have also been affected by exposure, including an increase in chromosomal fragments in the cells (HSDB). The **oral cancer slope factor for DDT (0.34) is used for total DDTs in this HHRA**, in accordance with EPA (2000) recommendations. EPAs IRIS database also provides an **inhalation unit risk of 9.70E-05 (µg/m³)⁻¹**.

17. Dichloromethane

Acute Toxicity

Inhalation of large amounts of dichloromethane can cause dizziness, nausea and numbness in fingers and toes. Inhalation of small amounts can cause a loss of focus and hand-eye coordination. Dermal exposure can cause burning and redness of the skin (ATSDR 2000b).

Chronic Toxicity

The chronic toxicity of dichloromethane is not well documented. EPAs IRIS database provides an **RfD for dichloromethane of 0.06 mg/kg-day**.

Carcinogenicity

Inhalation of large amounts over time of dichloromethane has been found to cause cancer in mice (ATSDR 2000b). EPAs IRIS database classifies dichloromethane as a probable (Group B2) human carcinogen. The IRIS database provides an **oral cancer slope factor of 0.0075 kg/mg-day⁻¹ and an inhalation unit risk of 4.70E-07 µg/m³**.

18. Ethylbenzene

Ethylbenzene occurs naturally in coal tar and petroleum. Ethylbenzene is also used in products such as inks, pesticides, and paints but is most commonly used to make styrene. It can also be used as a solvent, in fuels and to fabricate other chemicals (ATSDR 2007c).

Acute Toxicity

Inhalation of high levels of ethylbenzene can cause irritation of the eyes and throat and dizziness. Animals that inhaled low concentrations of ethylbenzene for several days to weeks exhibited inner ear damage and hearing loss (ATSDR 2007c).

Chronic Toxicity

Long-term (months to years) exposure to ethyl benzene via inhalation had been found to cause kidney damage in animals (ATSDR 2007c). EPAs IRIS database provides an **RfD for ethylbenzene of 0.1 mg/kg-day** and an **RfC of 1 mg/m³**.

Carcinogenicity

EPAs IRIS database identifies ethylbenzene as not classifiable as to human toxicity (Group D). The California EPA provides an **oral cancer slope factor for ethylbenzene of 0.011 kg/mg-day⁻¹** and an **inhalation unit risk of 2.50E-06 µg/m³**.

19. Iron

Iron is the second most abundant metal in the earth's crust. The most common iron ores include hematite, magnetite, limonite, and siderite (HSDB). Iron salts are used as fertilizer micronutrients, herbicides, electrolytes in dry cell batteries, animal feed additives, galvanizers, and as emulsion breakers. The major route of exposure to iron is through the mining and handling of iron ores (HSDB).

Acute Toxicity

Acute iron toxicity is the main cause of pediatric poisoning death in the United States. The hallmark feature of iron overdose is gastrointestinal bleeding. Iron is an extremely corrosive substance in the gastrointestinal tract. The absorption of excessive quantities of ingested iron will result in systemic iron toxicity. Severe overdose causes impaired mitochondrial dysfunction, which can result in cellular death. One of the most affected organs is the liver, but other organs, such as the heart, kidneys, lungs and the hematologic systems may be impaired (Spanierman 2001).

Chronic Toxicity

Chronic exposure to iron oxide fume or dust can cause the appearance of a pulmonary condition called siderosis. This is considered a benign condition and does not ordinarily cause significant physiologic impairments (HSDB). Iron is also suspected to be a cardiovascular or blood toxicant, gastrointestinal or liver toxicant, neurotoxicant, and respiratory toxicant (HSDB). EPA's NCEA has developed a **provisional RfD for iron of 0.7 mg/kg-day** (EPA 2005). Provisional RfDs have greater uncertainty than RfDs published by EPA in the IRIS database.

Carcinogenicity

At this time, there is no information regarding the carcinogenicity of iron to humans or animals.

20. Lead

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead's most important industrial use is in the production of some types of batteries. It is also used in the production of ammunition, in some kinds of metal products (such as sheet lead, solder, some brass and bronze products, and pipes), and in ceramic glazes. Human activities (such as the former use of "leaded" gasoline) have spread lead and substances that contain lead to all parts of the environment. Before the use of leaded gasoline was banned, most of the lead released into the US environment came from car exhaust. Other sources of lead released to the air include burning fuel, such as coal or oil, industrial processes, and burning solid waste.

Sources of lead in dust and soil include lead that falls to the ground from the air, and weathering and chipping of lead-based paint from buildings and other

structures. Lead in dust may also come from windblown soil. Disposal of lead in municipal and hazardous waste dump sites may also add lead to soil. Mining wastes that have been used for sandlots, driveways, and roadbeds can also be sources of lead (ATSDR 1999c).

People living near hazardous waste sites may be exposed to lead and chemicals that contain lead by breathing air, drinking water, eating foods, or swallowing or touching dust or dirt that contains lead. For people who do not live near hazardous waste sites, exposure to lead may occur in several ways: 1) by eating foods or drinking water that contain lead, 2) by spending time in areas where leaded paints have been used and are deteriorating, 3) by working in jobs where lead is used, 4) by using health-care products or folk remedies that contain lead, and 5) by having hobbies in which lead may be used such as sculpturing (lead solder) and staining glass.

Acute Toxicity

Lead can affect almost every organ and system in your body. The most sensitive is the central nervous system, particularly in children. Studies have shown that children exposed to low levels of lead have lower IQs, reduced motor skills, developmental problems, hyperactivity, and increased aggression (Canfield et al. 2003; Pattee and Pain 2003).

Lead also damages kidneys and the reproductive system. The toxic effects of lead are the same regardless of the route of entry into the body, and they are correlated with internal exposure as blood lead level.

Chronic Toxicity

At high levels over long periods of time, lead may decrease reaction time, cause weakness in fingers, wrists, or ankles, and possibly affect the memory. Lead may cause anemia, a disorder of the blood. It can also damage the male reproductive system. Even low levels of exposure to lead may have significant effects.

Since most of the toxicity data for lead is based on an internal dose, a reference dose, which is based on an external dose (i.e., mg/kg-day) has not been developed. Data on external exposure (i.e., mg/kg-day) are available from animal studies, but these data are generally not used to assess human health impacts because of the large database available using blood levels. Risks from lead exposure were evaluated using the IEUBK model for young children and the adult lead model for risks to fetal development, as described in Section B.3.4.4. EPA and the Centers for Disease Control and Prevention have determined that child or fetal blood lead concentrations at or above 10 µg/dL present risks to children's health.

Carcinogenicity

The Department of Health and Human Services has determined that lead acetate and lead phosphate may reasonably be anticipated to be carcinogens based on studies in animals. There is inadequate information to clearly determine lead's carcinogenicity in people (ToxFAQs). EPA's IRIS database classifies lead as a probable (Group B2) human carcinogen.

21. Manganese

Manganese is an element considered essential to human health. However, divalent manganese is about 2.5 to 3 times more toxic than trivalent manganese, and the anions of manganese salts influence the overall manganese toxicity. Industrial activities which use manganese include steel manufacturing, nonferrous alloys, purifying and scavenging agent in metal production, manufacturing of aluminum, ceramics, matches, glass, and welding rods (HSDB).

Acute Toxicity

Acute manganese poisoning has effects similar to other heavy metals if dust or fumes are inhaled in sufficient quantity. The minimum dose that produces effects on the central nervous system is not known and, with few exceptions, such effects have been observed only in occupationally exposed individuals. Sixteen cases of manganese poisoning have been described for a small Japanese community, three of which were fatal (including one suicide). The manganese content of the water was about 14 mg/L and concentrations of about 8 and 11 mg/L were found in two other wells. The subjects exhibited psychological and neurological disorders associated with manganese poisoning and high manganese and zinc levels were found in organs at autopsy (WHO 1981).

Chronic Toxicity

The usual form of chronic manganese poisoning primarily involves the central nervous system. Early symptoms include, languor, sleepiness, and weakness in legs, emotional disturbances such as uncontrollable laughter and a tendency to fall while walking (ACGIH 1986). Long-term exposure to manganese is known to cause a condition with symptoms that are similar to Parkinson's disease and are debilitating and permanent. Exposure to this metal has also been linked to reproductive problems and reduced red and white blood cell counts (ATSDR 2000a).

Experimental studies have suggested that populations at greatest risk of adverse effects due to manganese exposure are the very young and those with an iron deficiency, and workers exposed to manganese at or near the recommended threshold limit value. EPA has established an **RfD of 0.14 mg/kg-day** for a 70 kg adult (IRIS). EPA's IRIS database also provides an **RfC of 0.00005 mg/m³**.

Carcinogenicity

Manganese is not classified as a carcinogen to humans (a Group D chemical) because existing studies are inadequate to assess the carcinogenicity of manganese to humans and animals (ToxFAQs).

22. Mercury

Mercury is widely distributed in the environment due to both natural and anthropogenic processes. It is released generally as elemental mercury (Hg⁰) or divalent mercury (Hg²⁺). It can be converted between these forms and may form mercury compounds by chemical processes in air, water, and soil. Biological processes in other media, primarily soil and sediment, can convert inorganic mercury into organic mercury, primarily methylmercury. In fish tissue, the majority of mercury is in the form of methylmercury (EPA 2000). Because mercury is only

a COPC for the fish consumer scenario, the toxicity values for methylmercury were used in this HHRA.

Acute Toxicity

Acute high-level exposures to methylmercury may result in kidney damage and failure, gastrointestinal damage, cardiovascular collapse, shock, and death. The estimated lethal dose is 10 to 60 mg/kg-day (ATSDR 1999d).

Chronic Toxicity

Neurotoxicity is the chronic effect of greatest concern, both to the developing embryo or fetus and to adults and children (EPA 2000). Neurotoxicological effects include tremors, decreased IQ, and decreased motor function. In addition, damage to the liver and kidney can occur with chronic exposure (ATSDR 1999d). Effects to humans from consumption of contaminated food have been documented in Japan and Iraq.

The current IRIS **RfD for methylmercury of 0.0001 mg/kg-day** was originally based on data on neurological changes in 81 Iraqi children who had been exposed *in utero*. This value was subsequently updated using data from a population in the Faroe Islands who were exposed to methylmercury and PCBs through consumption of fish and pilot whale. In deriving the RfD, EPA used a benchmark dose (BMD) approach to quantify a dose-effect relationship between methylmercury in cord blood and a neurological endpoint. A BMD limit of 58 µg/L cord blood was estimated based on findings from the Boston Naming Test, a neuropsychological evaluation. A methylmercury intake level associated with a blood level of 58 µg/L was then calculated to be 1.0 µg/kg-day. The current RfD of 0.1 µg/kg-day (i.e., 0.0001 mg/kg-day) derived from the Faroe Islands data, is thus unchanged from the previous RfD derived from the Iraqi data. The RfD for methylmercury is used for mercury in this HHRA.

Carcinogenicity

Methylmercury is currently a Group C chemical, a possible carcinogen based on inadequate data in humans and limited evidence in animals. Dietary exposure of mice to methylmercury resulted in significant increases in the incidences of kidney tumors in males but not in females (EPA 1997c). Evidence points to a mode of action for methylmercury carcinogenicity that operates at high doses certain to produce other types of toxicity in humans. Given the relatively low levels of exposure, even among consumers of highly contaminated fish, methylmercury is not likely to present a carcinogenic risk to the US population (EPA 2000). An oral slope factor is currently not available for methylmercury.

23. Naphthalene

Naphthalene can be found in petroleum and coal, and is produced from burning wood or tobacco. Currently naphthalene is used to manufacture polyvinyl chloride (PVC) plastics. It is also used as a moth repellent and as a toilet deodorizer (ATSDR 2005b).

Acute Toxicity

Exposure to high levels of naphthalene can destroy red blood cells which can lead to hemolytic anemia. A decrease in the amount of red blood cells can lead to fatigue, loss of appetite, restlessness, and pale skin. Exposure to high levels of

naphthalene can also cause nausea, vomiting, diarrhea, blood in the urine, and a yellow color to the skin. Ingestion of high levels of naphthalene has been associated with cloudy eyes in animals (ATSDR 2005b).

Chronic Toxicity

Irritation and inflammation of the nose and lungs occurred when mice and rats inhaled naphthalene for long periods of time. Ingestion of naphthalene. Abnormal materials accumulated in the lungs of mice when they ingested naphthalene related compounds over a lifetime (ATSDR 2005b). EPAs IRIS database provides on **oral RfD for naphthalene of 0.02 mg/kg-day and an RfC of 0.003 mg/m³**.

Carcinogenicity

Mice that inhaled naphthalene over a lifetime developed tumors in their lungs. Rats that inhaled naphthalene over a lifetime also developed tumors in their noses (ATSDR 2005b). EPAs IRIS database classifies naphthalene as a possible (Group C) human carcinogen. California EPA provides an **inhalation unit risk of 0.000034 (µg/m³)⁻¹**.

24. Nickel

Nickel is used in a wide variety of industries. Occupational exposure is the predominant cause of harmful exposure to nickel.

Acute Toxicity

Dermal contact with nickel causes contact dermatitis. Nickel poisoning occurred in 23 dialyzed patients when nickel leached in dialysate from a nickel-plated stainless steel water heater. The victims experienced nausea, vomiting, weakness, headache, and palpitation (HSDB).

Chronic Toxicity

Nasal and lung cancer have resulted from chronic inhalation of nickel particles (IRIS). Damage to the nasal mucosa, asthma, pneumoconiosis, and conjunctivitis have also been observed after long term exposure (HSDB). EPA has developed an **RfD of 0.02 mg/kg-day for nickel** based on decreased body and organ weights in a long-term rat feeding study (IRIS).

Carcinogenicity

EPA has classified nickel refinery dust as a known (Group A) carcinogen, but the soluble salts of nickel on which the oral RfD is based are not classified as carcinogenic. This classification was based on a study of sulfide nickel matte refinery workers who developed lung and nasal tumors after being exposed to nickel refinery dust, and also on data collected from nickel carcinogenicity studies with rats (IRIS).

25. n-Propylbenzene

There is limited information on the toxicity of n-propylbenzene. Ethylbenzene was used a surrogate in the HHRA. N-propylbenzene occurs naturally in petroleum and bituminous coal. N-propylbenzene has been used in dyeing and printing (ATSDR 2007a).

Acute Toxicity

There is limited information on the acute effects of exposure to n-propylbenzene. N-propylbenzene is a respiratory irritant. It can be toxic to internal organs if absorbed through the skin (LookChem 2008).

Chronic Toxicity

There is limited information on the chronic effects of exposure to n-propylbenzene. N-propylbenzene can cause lung damage and death from aspiration (LookChem 2008). EPA has derived an **RfD of 0.1 mg/kg-day** for n-propylbenzene's surrogate ethylbenzene based on liver and kidney toxicity in a long-term rat feeding study (IRIS). EPA's IRIS database also provides an RfC for ethylbenzene of 1 mg/m³ based on developmental inhalation studies in rats and rabbits.

Carcinogenicity

There is limited information on the chronic effects of exposure to n-propylbenzene.

26. Polychlorinated biphenyls (PCBs)

Although the production and use of PCBs were banned in this country in 1979, this chemical group is extremely persistent in the environment and bioaccumulates through the food chain (EPA 2000). There is evidence that some dioxin-like PCB congeners, which are assumed to be the most toxic, preferentially accumulate in organisms higher on the food chain, including humans. As a result, the composition of PCB mixtures in fish tissue may differ significantly from the environmental PCB source. Often the mixtures of interest are not those that have been used in studies of laboratory animals to determine toxicity (EPA 2000).

Acute Toxicity

Studies in animals have shown that exposure to very high doses of PCBs can cause death. However, doses of such magnitude are unlikely in environmental exposures and current industrial settings. There have been no reports of deaths in humans after exposure to PCBs even where exposures were much higher than those typically identified with environmental exposures (ATSDR 2000c).

Chronic Toxicity

Numerous effects have been documented in animal studies including hepatic, gastrointestinal, hematological, dermal, body weight, endocrine, immunological, neurological, reproductive, developmental, and liver cancer (ATSDR 2000c). One of the most distinct effects associated with PCB exposure is the skin condition chloracne, which is generally associated with high levels of exposure (ATSDR 2000c). Evidence of other chronic effects in humans is not nearly as definitive. Several studies in humans have suggested that PCB exposure, particularly via in utero exposure through maternal fish consumption, may cause adverse effects in children and in developing fetuses (ATSDR 2000c). Neurobehavioral effects in such children with a range of PCB exposure levels have been documented by Fein et al. (1984), Jacobson and Jacobson (1996, 1997), and Schantz (1996). A review of exposure evaluation in 10 more recent studies associating neurodevelopmental effects with PCBs is also available (Longnecker et al. 2003).

This will facilitate future comparisons across studies and future updates to neurodevelopmental toxicity metrics. PCBs have also been associated with immunological effects in several epidemiological studies (Dallaire et al. 2006).

Over intermediate durations (i.e., less than 10% of an organism's lifetime), learning problems have been noted in monkeys fed PCB mixtures similar in composition to human breast milk (ATSDR 2000c). Some studies also indicate a possible connection between PCB exposure and cardiovascular effects; although this has been better demonstrated in assessments of dioxins, which share a similar chemical structure to PCBs (see structure activity relationships at the end of the PCB section).

EPA has derived an **RfD of 0.00002 mg/kg-day** for Aroclor 1254 (IRIS). The RfD was based on a LOAEL of 0.005 mg/kg-day for ocular and immunological effects in monkeys. This RfD is considered to be protective of developmental effects as well, and is used for total PCBs in this HHRA.

Carcinogenicity

PCBs are classified by EPA as Group B2, probable human carcinogens. This designation is based on studies that have found liver tumors in rats exposed to Aroclors 1260, 1254, 1242, and 1016. Occupational mortality data indicate that exposures to PCBs during capacitor manufacturing and repairing were associated with cancer of the liver, biliary tract and/or gall bladder, intestinal cancer, and skin melanoma (Brown and Jones 1981; Brown 1987); however, previous reviews of human epidemiological studies of PCBs have not yielded conclusive results (Silberhorn et al. 1990). Some more recent studies have indicated an increase in melanoma, brain, prostate, or liver cancer mortality in populations occupationally exposed to PCBs (Prince et al. 2006a; Prince et al. 2006b; Ruder et al. 2006). Elevated risk of non-Hodgkin lymphoma has been associated with detection of PCBs in carpet dust (Colt et al. 2005) and in elevated PCB concentrations in blood (De Roos et al. 2005).

EPA has developed a range of slope factors for PCBs (EPA 1996). Using information on environmental processes, they have provided guidance for choosing an appropriate slope factor based on the class of the mixture and the exposure pathway. Because bioaccumulated PCBs appear to be more toxic and more persistent in the body than commercial PCBs, **the upper bound slope factor associated with high risk and persistence (2.0 per mg/kg-day) was used in this HHRA** (IRIS). EPA's IRIS database also provides an **inhalation unit risk of 0.0001 ($\mu\text{g}/\text{m}^3$)⁻¹**.

When assessing PCB mixtures, it is important to recognize that both dioxin-like and non-dioxin-like modes of action contribute to overall PCB toxicity. It is possible that concentrations of dioxin-like congeners are increased in an environmental mixture. When congener concentrations are available, the mixture-based approach based on Aroclor analyses can be supplemented by analysis of dioxin TEQs to evaluate the PCB congeners with dioxin-like toxicity. In the TEQ approach, all PCB congeners with dioxin-like properties are analyzed in order to assess their impact on the overall risk from PCBs. For the analysis of dioxin-like PCB congeners, the **dioxin slope factor of 150,000 per mg/kg-day** (EPA 2005) is used with the estimated dioxin toxic equivalency (Van den Berg et al. 2006). Details of the structure activity relationship are presented below. The TEFs for PCBs are presented in Section B.2.2.

Structure Activity Relationships

Some non- and mono-ortho substituted PCBs may adopt a planar conformation and activate the aryl hydrocarbon (Ah) receptor. These PCBs are thought to share a common mode of toxic action with dioxin (2,3,7,8-TCDD) and are sometimes referred to as dioxin-like PCBs (Van den Berg et al. 2006). Some polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are also capable of activating the Ah receptor and also have TEFs (see Section B.2.2). The mono-ortho substituted PCBs have higher TEFs because they are structurally better able to take on the planar conformation needed to activate the Ah receptor.

A recent study assessed cancer in rodents exposed to an equal TEQ quantity from either one PCB, one PCDF, a mixture (equal parts of one PCB, one PCDF, and TCDD), or TCDD (Walker et al. 2005). The results of this study supported the use of the TEF approach for the estimation of PCB cancer risk.

PCBs used in most laboratory studies and found in the environment are complex mixtures, and it is not known exactly what portion of observed effects is attributable to dioxin-like or non-dioxin-like PCBs. The EPA Science Advisory Board cited the van der Plas et al. (2000) study of rats exposed to Aroclor 1260, which suggested that most of the tumor promotion potential of PCB mixtures is attributable to the non-dioxin-like fraction (EPA 2001). Because this fraction is not included in the TEQ calculation, van der Plas et al. (2000) concluded that the tumor promotion potential of PCBs might be underestimated by the TEQ approach alone. This is also supported by estimates of TEQs for the different Aroclors. Although EPA's SF included consideration of several Aroclors, the SFs for 1260, followed by 1254, were the highest in the studies evaluated and were used for the development of the SF for total PCBs (EPA 1996). The TEQ potency for Aroclor 1260 on a mass basis is lower than the potencies for several other Aroclors (Rushneck et al. 2004; Van den Berg et al. 2006). This also suggests that some of its carcinogenic potency is not attributable to dioxin-like PCB congeners.

Another recent review also supports PCB carcinogenicity as acting through an indirect mechanism, such as tumor promotion (rather than initiation) (Knerr and Schrenk 2006). Across the carcinogenicity studies evaluated, the TEQ dose (but not the total PCB dose) was found to be primarily responsible for the development of neoplasms in rats. However, tumor promotion experiments in rodents have shown that both dioxin-like and non-dioxin-like PCB congeners may act as liver tumor promoters. In the case of the van der Plas (2000) study, Knerr and Schrenk (2006) asserted that the purity data provided in that study were not sufficient to exclude the potential contribution of some dioxin-like PCB congeners to the observed toxicity (Knerr and Schrenk 2006). Although the dioxin-like PCB congeners showed much greater potency, some weak carcinogenic potency of non-dioxin-like PCBs cannot be excluded (Knerr and Schrenk 2006). For this reason, some scientists have suggested that the carcinogenic evaluation of PCBs based solely on PCB TEQ evaluation is not sufficient (Safe 1994). Research and debate is active on the most appropriate methods to evaluate carcinogenic potential of environmental PCB mixtures.

The contribution of dioxin-like and non-dioxin-like PCBs to non-cancer effects is also an area of active research and discussion. Unlike carcinogenicity, health

risks from PCBs associated with these effects are not evaluated on a TEQ basis. For these endpoints, non-dioxin-like PCBs may play a greater role than they do in carcinogenicity. The mechanisms of action for PCB neurotoxicity are not thought to be mediated by the Ah receptor, suggesting that non-dioxin-like PCBs may be important. However, the specific PCB congeners involved have not been well-characterized. It is possible that the most potent congeners for these endpoints may be enhanced or diluted in environmental mixtures relative to mixtures used to develop toxicity metrics. For example, environmental mixtures of PCBs may have more- or less-potent immunological effects than do the Aroclor 1254 mixture used in the study that is the basis for the reference dose.

27. tert-Butyl methyl ether (MTBE)

Tert-Butyl methyl ether (MTBE) is not naturally occurring and can be made by blending chemicals such as isobutylene and methanol. MTBE is added to unleaded gasolines, which results in more efficient burning of the gasoline. MTBE has been used for this purpose since the 1980s. It is also used medically to dissolve gallstones (ATSDR 1996b).

Acute Toxicity

Inhalation of small amounts of MTBE can cause nose and throat irritation. Symptoms such as headaches, nausea, dizziness, and mental confusion have been reported after inhalation of gasoline fumes but it is not clear whether these effects are directly associated with MTBE or other chemicals. Ingestion of MTBE by mice and rats caused gastrointestinal irritation, liver and kidney damage, and nervous system effects (ATSDR 1996b).

Chronic Toxicity

The chronic toxicity of MTBE is not well documented. EPA's IRIS database provides an RfC for tert-Butyl methyl ether of 3 mg/m^3 .

Carcinogenicity

One study with rats concluded that inhalation of high levels of MTBE caused kidney cancer. Another study with mice found that inhalation of high levels of MTBE caused liver cancer (ATSDR 1996b). California EPA provides an **oral cancer slope factor of $0.0018 \text{ kg/mg-day}^{-1}$ and an inhalation unit risk of $2.60\text{E-}07 (\mu\text{g/m}^3)^{-1}$** .

28. Total petroleum hydrocarbons

Total petroleum hydrocarbons (TPH) describe a broad list of hundreds of related chemical compounds that originally come from crude oil. TPH have widespread use and can be found in petroleum products including gasoline, kerosene, fuel oil, mineral oil, and asphalt (ATSDR 1999e). Health effects of TPH are typically classified based on TPH fraction or based on whole petroleum products (complex mixtures such as fuel oils or gasoline).

Acute Toxicity

Acute exposure to gasoline via various routes (i.e., inhalation, oral, or dermal exposure) has been associated with skin irritation, headache, nausea, dizziness, euphoria, and drowsiness. Ingestion of large amounts of gasoline can cause

respiratory effects such as pneumonitis and pulmonary edema due to the aspiration of gasoline (ATSDR 1999e).

Chronic Toxicity

PPRTV provides an **oral RfD of 0.3 mg/kg-day for TPH-gasoline (aliphatic)** based on reduced nerve connection velocity and **inhalation RfC of 0.6 mg/m³** based on nasal epithelial cell hyperplasia. PPRTV also provides an **oral RfD of 0.01 mg/kg-day for TPH-diesel (aliphatic)** based on liver, kidney, and hematologic effects.

Carcinogenicity

PPRTV provides an **inhalation unit risk of 0.00000019 µg/m³** for TPH-gasoline (aliphatic).

29. Trichloroethene

Trichloroethene (TCE) does not occur naturally and is most commonly used as a solvent to remove grease from metal. TCE is also used in adhesives, paint removers, typewriter correction fluids, and spot removers (ATSDR 1997).

Acute Toxicity

Inhalation of small amounts of TCE can cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Inhalation of larger amounts can cause impaired heart function, unconsciousness, and death. Ingestion of large amounts of TCE can cause nausea, liver damage, unconsciousness, impaired heart function, or death. Dermal exposure can cause skin rashes (ATSDR 1997).

Chronic Toxicity

Inhalation of TCE over time can cause nerve, kidney, and liver damage. Ingestion of small amounts of TCE over time can cause damage to the liver and kidney, reduced immune system function, and reduced fetal development in pregnant women.

Carcinogenicity

Exposure to high levels of TCE caused liver, kidney and lung cancer in mice and rats. Studies that looked at humans exposed to TCE in drinking water found that they were more likely to develop cancer than humans who were not exposed (ATSDR 1997). California EPA provides an **oral cancer slope factor for trichloroethene of 0.13 kg/mg-day⁻¹** and an **inhalation unit risk of 0.00002 µg/m³**.

30. Vanadium

Vanadium compounds are widely distributed in the earth's crust. Elemental vanadium does not occur in nature, but its compounds exist in over 50 different mineral ores and in association with fossil fuels (HSDB). The route of entry of vanadium compounds most commonly seen in industrial exposures is through the respiratory system. Exposures are usually limited to areas where vanadium pentoxide is produced, in steel mills where vanadium pentoxide is used, and in cleaning boilers fired by oil containing vanadium (HSDB).

Acute Toxicity

Vanadium and its compounds are principally eye and respiratory tract irritants that result in conjunctivitis, coughing, wheezing, difficulty in breathing, and industrial bronchitis. A metallic taste and throat irritation may occur. Greenish discoloration of the fingers, scrotum, and upper legs may also be present. A greenish black discoloration of the tongue indicates heavy exposure (HSDB).

Chronic Toxicity

Some studies suggest exposure to vanadium may impair the lung resistance to respiratory infection, although the available data on chronic respiratory effects of vanadium are still inconclusive. EPA's RSL table provides an **RfD of 0.005 mg/kg-day** for vanadium and compounds (based on a molecular weight-based adaptation of the vanadium pentoxide RfD of 0.009 mg/kg-day from IRIS).

Carcinogenicity

At this time, there is no information regarding the carcinogenicity of vanadium to humans or animals.

31. Vinyl chloride

Vinyl chloride does not occur naturally in the environment but can be formed as a result of degradation of other chemicals such as trichloroethane, trichloroethylene, and tetrachloroethylene. Vinyl chloride is currently used to make PVC (ATSDR 2006c).

Acute Toxicity

Inhalation of high levels of vinyl chloride can cause dizziness, sleepiness, unconsciousness or death. Vinyl chloride can also cause nerve damage, liver damage, and immune reaction, but the concentrations needed for these affects to occur are unknown. Humans exposed to high levels of vinyl chloride observed low blood flow in their hands and their fingers developed a white color and were sensitive to cold. Dermal exposure can cause numbness, redness and blisters (ATSDR 2006c).

Chronic Toxicity

Humans who have inhaled vinyl chloride over time have observed changes in their liver. Animals that were exposed over time had damage to the sperm and testes (ATSDR 2006c). EPA's IRIS database provides an **RfD for vinyl chloride of 0.003 mg/kg-day and an RfC of 0.1 mg/m³**.

Carcinogenicity

Humans who inhaled vinyl chloride over time developed an increased risk of liver, brain, lung cancer, and cancers of the blood (ATSDR 2006c). EPA's IRIS database has classified vinyl chloride as a human (Group A) carcinogen. EPA's IRIS database provides an **oral cancer slope factor for non-occupational exposure to vinyl chloride of 1.5 kg/mg-day⁻¹** and an **inhalation unit risk factor of 0.0000088 µg/m³**. IRIS also provides an **oral cancer slope factor for occupational exposure to vinyl chloride of 0.72 kg/mg-day⁻¹** and an **inhalation unit risk factor of 0.0000044 µg/m³**.

32. Xylenes

Xylenes are composed of three different isomers *m*-, *o*-, and *p*-xylene. Xylenes are naturally occurring in petroleum and coal tar. It is one of the 30 most produced chemicals by volume in the United States. It is currently used as a solvent and in the printing, rubber, and leather industries. Xylene is also used as a cleaning agent, a thinner for paint, and in paints and varnishes. It can also be found in airplane fuel and gasoline (ATSDR 2006d).

Acute Toxicity

High levels of Xylene can cause headaches; a reduction in muscle coordination; dizziness; confusion; disruption of the sense of balance; irritation of the skin, eyes, nose, and throat; difficulty in breathing; problems with the lungs; delayed reaction time; memory difficulties; stomach discomfort; and possibly changes in the liver and kidneys and death (ATSDR 2006d).

Chronic Toxicity

The chronic toxicity of xylenes is not well documented. EPA's IRIS database provides an **RfD for xylenes of 0.2 mg/kg-day and an RfC of 0.1 mg/m³**.

Carcinogenicity

The carcinogenicity of xylenes is not well documented. RAIS identifies xylenes as not classifiable as to human carcinogenicity (Group D).

33. Zinc

Zinc is an essential trace element that plays a necessary role in enzymatic functions, protein synthesis, and carbohydrate metabolism. Small doses of zinc are necessary for normal growth and development in birds and mammals. Zinc also has many industrial uses. It is used as a galvanizing agent, component in brass, bronze alloys, light metal alloys, and in wet batteries (HSDB). The most common route of high-level exposure to zinc is through consumption of liquid contained in galvanized metal containers or by water contaminated with industrial zinc waste (ToxFAQs).

Acute Toxicity

In humans, ingestion of gram quantities of zinc may cause pancreatic derangement, light-headedness, and mild derangement of cerebellar function. Acute exposure to zinc can also cause dizziness, nausea, tightness in the throat, diarrhea, and vomiting. Metal fume fever has been observed after inhalation of zinc oxide fumes (HSDB).

Chronic Toxicity

Prolonged exposure to drinking water that contained 40 mg/L of zinc triggered symptoms such as irritability, muscular stiffness and pain, loss of appetite, and nausea (HSDB). EPA has established an **RfD of 0.3 mg/kg-day for zinc** based on a human diet supplement study in which adult females experienced a 47% decline in erythrocyte superoxide dismutase (ESOD) after 10 weeks of exposure (IRIS).

Carcinogenicity

EPA has placed zinc in Group D, not classifiable as to human carcinogenicity (IRIS).

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ATTACHMENT 7 – BACKGROUND AND REFERENCE AREA CONCENTRATIONS

1.0 Introduction

US Environmental Protection Agency (EPA) guidance discusses two types of background concentrations, natural and anthropogenic. Natural background is defined as “naturally occurring substances present in the environment in forms that have not been influenced by human activity.” Anthropogenic background is defined as “natural and human-made substances present in the environment as a result of human activities (not specifically related to the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] site in question)” (EPA 2002). As recommended in EPA (2002) guidance, background concentrations of COPCs at the Harbor Oil Study Area (when available) are discussed in the human health risk assessment (HHRA) after the initial risk estimates for these COPCs are presented (Section 5.3).

This attachment discusses background concentrations for metals that were available from Oregon Department of Environmental Quality (DEQ) and reference area concentrations for organic compounds. The term reference area is used instead of background for organic compounds because no specific background concentrations that are representative of anthropogenic background have been selected or approved by EPA. Instead, concentrations from reference areas (urban areas within the vicinity of the Study Area) are presented for comparison with Study Area concentrations.

This attachment to the Harbor Oil baseline HHRA presents the background or reference area concentrations used in the risk characterization section of the HHRA. Sources of background or reference area concentrations for the Harbor Oil HHRA include the following:

- DEQ's Memorandum from Toxicology Workgroup to DEQ Cleanup Program Managers Regarding Default Background Concentrations for Metals (DEQ 2002). This memorandum presents regional soil and sediment background concentrations for metals, including arsenic.
- DEQ's *Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment* (DEQ 2007). This document presents regional soil and sediment background concentrations for metals, including arsenic.
- Radio Tower Site (URS 2000). Five samples were collected as part of a preliminary soil investigation at the Radio Tower Site across North Force Avenue from Harbor Oil. One of these samples was designated as a “background location” for the sampling event, but because concentrations at this location were generally similar to the other four samples, all samples from the Radio Tower Site were used to represent reference area concentrations for the HHRA. Samples were analyzed for hydrocarbons, metals, pesticides, herbicides, and semi-volatile organic compounds (SVOCs).

- DEQ's Columbia Slough Sediment Project (DEQ 2005). Baseline sediment concentrations for the Columbia Slough, which drains over 30,000 acres of urban land in the City of Portland, were used to represent reference area concentrations for the HHRA. These baseline maxima concentrations are calculated values meant to reflect the upper end of the range of concentrations throughout the slough (i.e., maximum concentrations excluding those associated with a particular source). These concentrations are relevant because they indicate the concentrations of chemicals present in the watershed associated with historical and current land uses (e.g., urban activities such runoff from roads, agricultural runoff). Concentrations were developed from samples taken since the early 1990s, and are available for volatile organic compounds (VOCs), phthalates, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and metals.

The Radio Tower Site and the Columbia Slough are shown on Figure 1 to provide information regarding the proximity of these regional sources to the Harbor Oil Study Area.

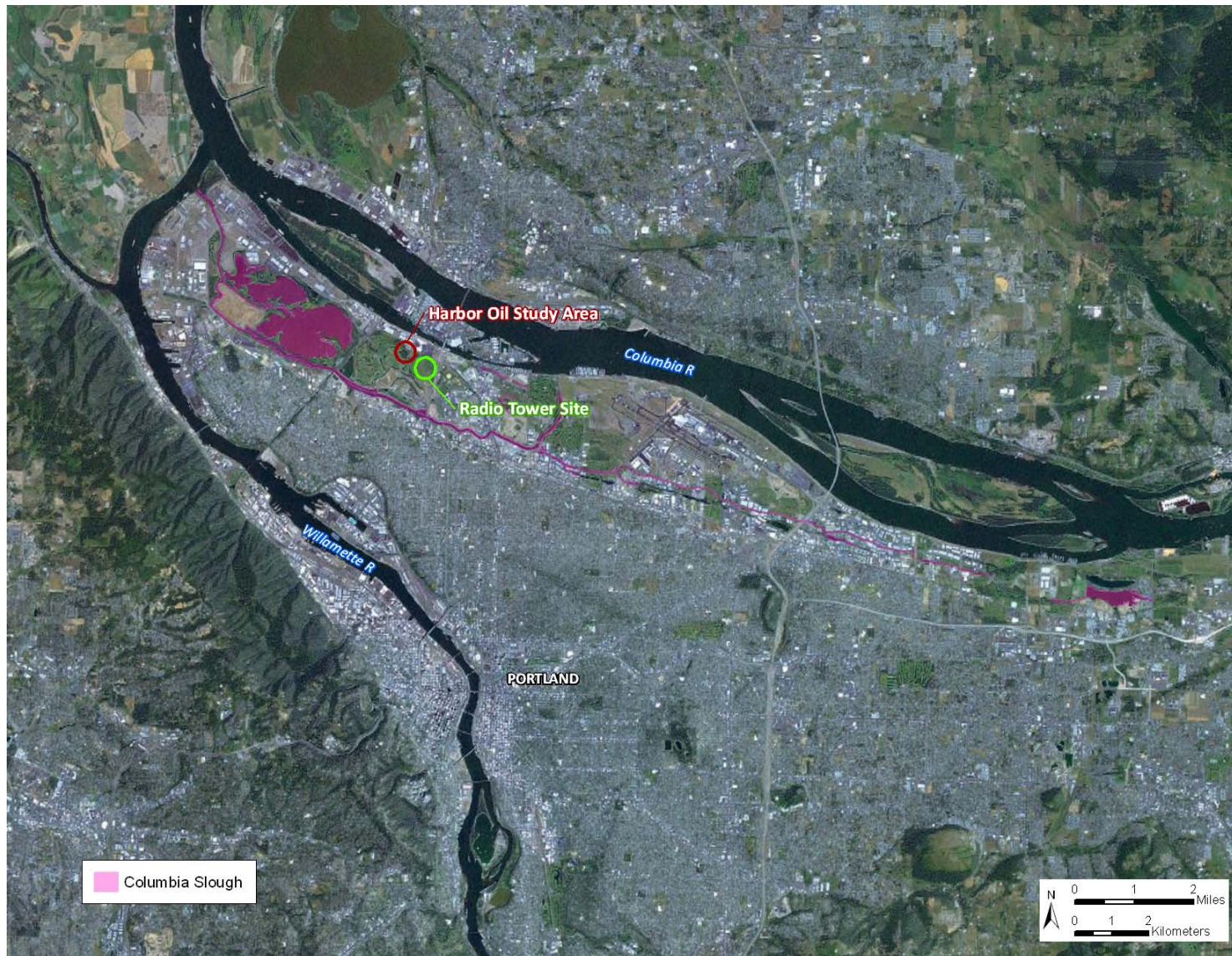


Figure 1. Locations of regional studies used to define reference area concentrations

This attachment discusses the background or reference area concentrations for only those COPCs with risk estimates greater than either an excess cancer risk of 1×10^{-6} or a non-cancer HQ of 1. These COPCs include arsenic, cPAH toxic equivalent (TEQ), total PCBs, total DDTs, and aliphatic gasoline-range total petroleum hydrocarbons (TPH), which are discussed in the following sections.

2.0 Arsenic

Arsenic occurs naturally in all sediments and soils worldwide. Background arsenic concentrations of 7 mg/kg dw in soil/sediment and 7.9 mg/kg dw in sediment are provided in DEQ's Memorandum from the Toxicology Workgroup to DEQ Cleanup Program Managers Regarding Default Background Concentrations for Metals (DEQ 2002) and DEQ's *Guidance for assessing bioaccumulative chemicals of concern in sediment* (DEQ 2007). Ambient concentrations are also available from other sources, but the value from this DEQ source was given priority because it is recommended for use at cleanup sites. Table 1 presents a comparison of arsenic concentrations in the Harbor Oil Study Area with background concentrations.

Table 1. Arsenic Concentrations at the Harbor Oil Study Area Compared with Background

Medium	Unit	Harbor Oil Study Area		Background Concentration
		Concentration Range	EPC	
Facility soil ^a	mg/kg dw	0.7 to 20.6	8.3 to 11	7
Groundwater ^a	µg/L	0.2 U to 32.2	15	na
Wetland soil	mg/kg dw	1.5 to 53.1	9.6	7
Lake sediment	mg/kg dw	1.5 to 7	6.4	7 to 7.9
Lake surface water	µg/L	0.9 to 1.2	1.2	na
Fish tissue ^b	mg/kg ww	0.050 to 0.24	0.22	0.24 to 0.27

^a The range of EPCs from the worker RME scenarios is presented here.

^b Fish tissue concentrations were estimated using BSAFs (see Attachment 2).

BSAF – biota-sediment accumulation factor

RME – reasonable maximum exposure

dw – dry weight

U – not detected at given concentration

EPC – exposure point concentration

ww – wet weight

na – not available

As noted in Table 1, arsenic concentrations at the Harbor Oil Study Area were generally similar to the background concentrations of 7 mg/kg dw for soil and 7.9 mg/kg dw for sediment. The lake sediment and fish tissue EPCs were less than the background concentrations, and both the wetland soil and Facility soil EPCs were less than 2 times the background concentration.

3.0 cPAH TEQ

Reference area cPAH TEQs are available as follows:

- A range of 134 to 149 µg/kg dw from DEQ's Columbia Slough Sediment Project (2005), which represents calculated baseline maxima concentrations meant to reflect the upper end of the range of sediment concentrations throughout the slough that are not associated with a particular source
- A range of 8.2 to 56.4 µg/kg dw from five samples taken at the Radio Tower Site (URS 2000)

These ranges were used to represent reference area cPAH TEQs for comparison with Harbor Oil sediment and soil data, respectively (Table 2). Specific background cPAH TEQs have not been established by EPA or DEQ.

Table 2. cPAH TEQs at the Harbor Oil Study Area Compared to Reference Area Concentrations

Medium	Unit	Harbor Oil Study Area		Reference Area Concentration Range
		Concentration Range	EPC	
Facility soil ^a	µg/kg dw	4.2 U to 5,200	950 to 1,100	8.2 to 56.4
Groundwater	µg/L	0.091 U to 1.5 U	not a COPC	na
Wetland soil	µg/kg dw	4.3 U to 5,200	1,100	8.2 to 56.4
Lake sediment	µg/kg dw	4.2 U to 118	81	134 to 149
Lake surface water	µg/L	0.091 U	not a COPC	na
Fish tissue	µg/kg dw	nc	not a COPC	nc

^a The range of EPCs from the worker RME scenarios is presented here.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

COPC – contaminant of potential concern

dw – dry weight

EPC – exposure point concentration

na – not available

nc – not calculated

RME – reasonable maximum exposure

TEQ – toxic equivalent

U – not detected at given concentration

As shown in Table 2, the lake sediment EPC was less than the range of reference area concentrations for cPAH TEQs. The Facility soil and wetland soil EPCs were approximately one order of magnitude higher than the high end of the reference area concentration range.

4.0 Total PCBs

Reference area concentrations of total PCBs are available from one source, DEQ's Columbia Slough Sediment Project (2005). A range of 23 to 24 µg/kg dw (Aroclor 1254) was calculated from the data, which represents calculated baseline maxima concentrations meant to reflect the upper end of the range of sediment concentrations throughout the slough that are not associated with a particular source.

This range was used to represent reference area total PCB concentrations for comparison to Harbor Oil data for both sediment and soil because no soil concentrations were available (Table 3). Total PCBs were not analyzed in the samples collected from the Radio Tower Site. Specific background concentrations for total PCBs have not been established by EPA or DEQ.

Table 3. Total PCB Concentrations at the Harbor Oil Study Area Compared with Reference Area Concentrations

Medium	Unit	Harbor Oil Study Area		Reference Area Concentration Range
		Concentration Range	EPC	
Facility soil ^a	µg/kg dw	4.9 to 32,000	3,400 to 5,200	23 to 24
Groundwater	µg/L	0.10 U to 0.96 U	not a COPC	na
Wetland soil	µg/kg dw	31 U to 4,200	770	23 to 24
Lake sediment	µg/kg dw	32 U to 131	not a COPC	23 to 24 ^b
Lake surface water	µg/L	0.10 UJ	not a COPC	na
Fish tissue ^c	µg/kg ww	77 to 440	330	78 to 81

^a The range of EPCs from the worker RME scenarios is presented here.

^b No soil background value is available; soil background value is based on sediment.

^c Fish tissue concentrations were estimated using BSAFs (see Attachment 2).

BSAF – biota-sediment accumulation factor

na – not available

COPC – contaminant of potential concern

PCB – polychlorinated biphenyl

dw – dry weight

RME – reasonable maximum exposure

EPC – exposure point concentration

U – not detected at given concentration

J – estimated concentration

ww – wet weight

As shown in Table 3, both the wetland soil and the Facility soil EPCs were higher than the range of reference area concentrations for total PCBs. For fish tissue, the EPC was approximately 4 times greater than the high-end reference area concentration for total PCBs.

5.0 Total DDTs

Reference area concentrations of total DDTs are available as follows:

- A range of 16 to 19 µg/kg dw from DEQ's Columbia Slough Sediment Project (2005), which represents calculated baseline maxima concentrations meant to reflect the upper end of the range of sediment concentrations throughout the slough that are not associated with a particular source.
- A range of 15 to 355 µg/kg dw from five samples taken at the Radio Tower Site (URS 2000). It should be noted that the highest concentration (355 µg/kg ww) was substantially higher than the next highest concentration (55 µg/kg ww). However, because of the patchy nature of DDT concentrations in the region and because there was no indication that the maximum concentration was linked to a specific source, all five samples were determined to be acceptable to represent total DDT reference area concentrations in this HHRA.

These ranges were used to represent reference area total DDT concentrations for comparison with Harbor Oil sediment and soil data, respectively (Table 4). Specific background concentrations for total DDTs have not been established by EPA or DEQ.

Table 4. Total DDT Concentrations at the Harbor Oil Study Area Compared to Reference Area Concentrations

Medium	Unit	Harbor Oil Study Area		Reference Area Range
		Concentration Range	EPC	
Facility soil ^a	µg/kg dw	0.6 U to 78,000	11,000 to 16,000	15 ^b to 355
Groundwater ^a	µg/L	0.0071 J to 0.24 J	0.049	na
Wetland soil	µg/kg dw	1.9 UJ to 46,000	9,100	15 ^b to 355
Lake sediment	µg/kg dw	2.0 U to 250	not a COPC	16 to 19
Lake surface water	µg/L	0.010 U	not a COPC	na
Fish tissue ^c	µg/kg ww	81 to 407	300	25 to 30

^a The range of EPCs from the worker RME scenarios is presented here.

^b The low end of this range is the reporting limit; the concentration was not detected.

^c Fish tissue concentrations were estimated using BSAFs (see Attachment 2).

BSAF – biota-sediment accumulation factor

J – estimated concentration

COPC – contaminant of potential concern

na – not available

dw – dry weight

RME – reasonable maximum exposure

EPC – exposure point concentration

U – not detected at given concentration

As shown in Table 4, both the wetland soil and the Facility soil EPCs were higher than the range of reference area concentrations for total DDTs. Fish tissue concentrations were estimated from sediment concentrations using literature BSAFs (see Attachment 2) for both the Study Area and reference area conditions. Based on this analysis, the Study Area fish tissue EPC was higher than the range of reference area concentrations for total DDTs.

6.0 Aliphatic Gasoline-Range TPH

No background or reference area information for TPH was available from any of the sources used for other metals or organic chemicals discussed in this attachment (listed in Section 1.0). Thus, background or reference area concentrations of TPH are not presented in the HHRA.

7.0 References

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